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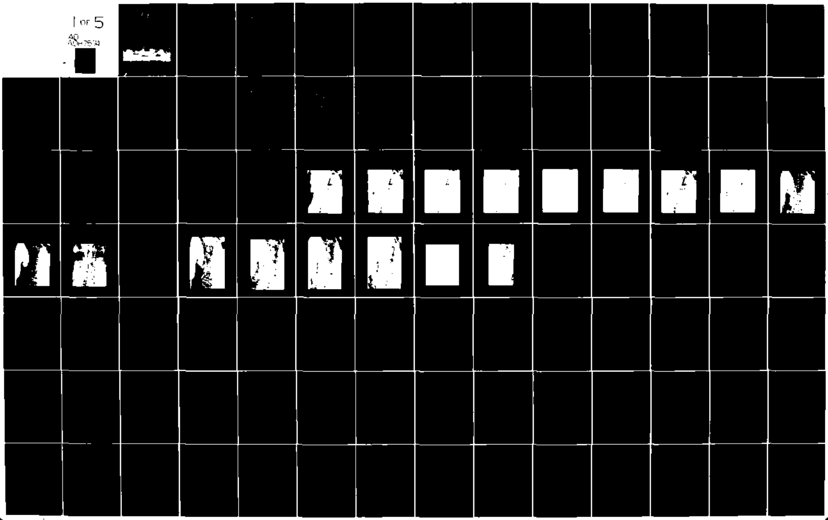

LEVEL II

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TECHNICAL REPORT EL-80-1

REMOTE-SENSING PROCEDURES FOR DETECTING AND MONITORING VARIOUS ACTIVITIES REGULATED BY THE MOBILE DISTRICT

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by

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Final Report

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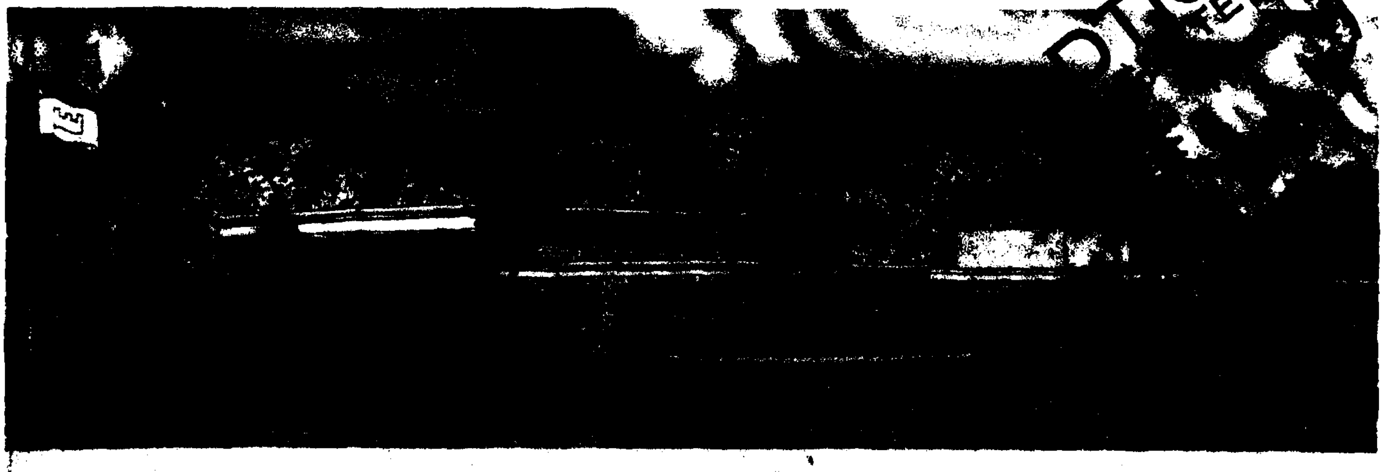

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aerial photography
Detection
Multispectral scanners
Remote sensing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to develop procedures for use by the U. S. Army Engineer District, Mobile, to detect and monitor activities requiring a Corps of Engineers permit pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972, Section 10 of the River and Harbor Act of 1899, and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972.

The detection and monitoring procedures developed in this study included → over

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20. ABSTRACT (Concluded).

three methods of acquiring remotely sensed data: satellite- and aircraft-borne digital scanner methods and airborne photographic methods. The two digital scanner systems investigated for the study were the Landsat Multispectral Scanner System and the National Aeronautics and Space Administration Modular Multispectral Scanner. The equipment and procedures used in these systems, which obtain the type of information required by the Regulatory Functions Branch, Mobile District, are described. Aerial photographic systems are described, and examples of several applications of detection and monitoring procedures involving wetlands, waterbodies, and structures are given. A summary of available remote-sensing imagery from Federal and State agencies is given.

The report includes appendices containing the following information: (a) instructions for reading map coordinates; (b) a description and listing of a computer program that converts geographic coordinates to Universal Transverse Mercator Coordinates and vice versa; (c) the development of film-filter matrices (arrays of numbers indicating the suitability of a particular film and filter combination to detect a given feature against a given background); (d) various state laws affecting permit activities in the Mobile District coastal areas; and (e) a photointerpreters' catalog of regulated activities.

PREFACE

The study was conducted from October 1976 to September 1978 at the U. S. Army Engineer Waterways Experiment Station (WES) by personnel of the Environmental Systems Division (ESD), Environmental Laboratory (EL).

The investigation reported herein was authorized by LTC D. R. Pope, Acting District Engineer, U. S. Army Engineer District, Mobile, Mobile, Alabama, 24 August 1976 and is in support of the Regulatory Functions Branch (RFB) of the Mobile District. The overall program managers at the Mobile District were Messrs. D. N. Conlon, Chief, RFB, and W. E. Workman, Geologist, RFB.

The study was conducted under the direct supervision of Mr. J. K. Stoll, Chief, Environmental Simulation Branch (ESB), and under the general supervision of Messrs. B. O. Benn, Chief, ESD, and W. G. Shockley, Chief, Mobility and Environmental Systems Laboratory. The ESD and ESB are now part of the EL of which Dr. John Harrison is Chief. Dr. H. Struve, Physicist, ESB, was responsible for the Landsat Multispectral Scanner and the Modular Multispectral Scanner analysis and evaluation. Dr. W. L. Kirk, ESB, was responsible for the mapping of the coastal jurisdictional areas. Drs. Struve and Kirk were responsible for preparing the report. Particular appreciation is expressed by the authors to Mrs. Ruby Britton, RFB, for her willing assistance throughout the study.

COL John L. Cannon, CE, and COL Nelson P. Conover, CE, were Commanders and Directors of the WES during the course of the study and report preparation. Mr. F. R. Brown was Technical Director.

CONTENTS

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	4046.856	square metres
cubic feet per second	0.028317	cubic metres per second
cubic yards	0.764555	cubic metres
degrees (angle)	0.017453	radians
feet	0.3048	metres
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometres
square feet	0.092903	square metres
square miles	2.589988	square kilometres
yards	0.9144	metres

REMOTE-SENSING PROCEDURES FOR DETECTING AND MONITORING VARIOUS ACTIVITIES REGULATED BY THE MOBILE DISTRICT

PART I: INTRODUCTION

Background

1. The Department of the Army, acting through the U. S. Army Corps of Engineers (CE), is responsible for enforcing Federal laws that regulate certain types of activities in specific waters in and surrounding the United States. Authorization for these regulatory programs is based primarily on various sections of the River and Harbor Act of 1899 (33 USC 401 et. seq.), Section 404 of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 (33 USC 1344), and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 USC 1413).

2. Several sections of the River and Harbor Act of 1899 bear on the Corps permit program, the most important being Section 10. By far, the largest volume of Corps permits under the Act falls in the jurisdiction of Section 10. This section prohibits unauthorized obstruction or alteration of any navigable water of the United States. The construction of any structure in or over any navigable water of the United States, the deposition of material in or the excavation from such waters, or any other work affecting the course, location, condition, or capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army.

3. The second major law under which the Corps permit program operates is Section 404 of the FWPCA. This section authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits, after notice and opportunity for public hearings, for the discharge of dredged or fill material into the navigable waters at specified disposal sites. The selection of disposal sites is in accordance with guidelines developed by the Administrator of the Environmental Protection Agency (EPA) in conjunction with the Secretary of the Army.

Furthermore, the Administrator can prohibit or restrict the use of any defined area as a disposal site whenever he determines, after notice and opportunity for public hearings, that the proposed discharge of materials into that area will have an adverse effect on municipal water supplies, shellfish beds, and fishery, wildlife, or recreational areas.

4. Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 USC 1413) is the third major law under which the Corps permit program operates. The provisions of this section stipulate that the Corps may authorize transportation of dredged material by vessel for the purpose of dumping it in ocean waters at designated dumping sites. The term "dredged material" means any material excavated or dredged from navigable waters of the United States ocean waters. The term "transport" or "transportation" refers to the carriage and related handling of dredged material by a vessel. "Designated dumping sites" are those sites at which ocean dumping will not result in an adverse impact on municipal water supplies, shellfish beds, wildlife, fisheries, or recreational areas.

5. In July of 1975, the definitions of "navigable waters," "fill material," and "dredged material" were revised. The significance of these revisions is the requirement for a Department of the Army permit for the disposal of dredged or fill material in virtually every natural and artificial water body in the United States, including wetland areas such as mudflats, marshes, swamps, bogs, and inland and coastal shallows contiguous to these waters, whether these areas are regularly or only periodically inundated by water. The major impact that these revisions have had on the Regulatory Functions Branch of the U. S. Army Engineer District, Mobile, as well as other Corps Districts throughout the United States, is to extend its jurisdictional boundaries to include thousands of square miles never before regulated.

6. In view of manpower and budgetary constraints, the law allowed the revised portion of the regulatory program to be phased in over a 2-year period. In Phase I, the regulation was to become immediately operative in all coastal waters and contiguous or adjacent wetlands, as well as inland rivers, lakes, and streams that are navigable waters of

the United States (which the CE was already regulating) and their contiguous or adjacent wetlands. In Phase II, beginning 1 July 1976, the CE was to continue regulating all discharges of dredged material occurring in those waters identified in Phase I and was also to begin regulating discharges of dredged or fill material in primary tributaries (the main stems of tributaries directly connecting to navigable waters of the United States), their contiguous or adjacent wetlands, and all lakes. Finally, in Phase III, all discharges of dredged or fill material in navigable waters were to be regulated after 1 July 1977. Navigable waters, as revised in the 1975 Code of Federal Regulations, include streams with flows normally 5 cfs* and greater and lakes (including their contiguous wetlands) larger than 10 acres.

7. Taking into consideration its vastly increased jurisdictional area and its manpower and budgetary limitations, the Mobile District was faced with the problem of processing an increased number of permit requests in compliance with the new laws while at the same time trying to maintain a reasonably short processing time. It was soon obvious to the Mobile District that old procedures for detecting and monitoring activities requiring a CE permit were inadequate and that new ones needed to be developed.

Objective

8. The objective of the study reported herein was for the U. S. Army Engineer Waterways Experiment Station (WES) to develop procedures for use by the Mobile District to detect and monitor activities requiring a CE permit pursuant to Section 404 of the FWPCA Amendments of 1972, Section 10 of the River and Harbor Act of 1899, and Section 103 of the Marine Protection, Research and Sanctuaries Act.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

Scope

9. The detecting and monitoring procedures developed in this study included three methods of acquiring remotely sensed data: satellite- and aircraft-borne digital scanner methods and airborne photographic methods. A representative area was identified within the Mobile District to demonstrate the application of the remotely sensed data to detect and monitor activities of interest to the Regulatory Functions Branch of the District. The way that the demonstration area was selected is described in Part II.

10. Two digital scanner systems were investigated for this study: the Landsat Multispectral Scanner Subsystem (MSS) and the National Aeronautics and Space Administration (NASA) Modular Multispectral Scanner (MMS). Descriptions of the equipment and procedures for using these systems for detecting and monitoring for acquisition of information of the types needed by the Regulatory Functions Branch are included in Part III. Aerial photographic systems are described in Part IV, which contains examples of the application of detection and monitoring procedures for activities involving wetlands, water bodies, and structures. Part V contains conclusions based on results of the study and recommendations for further study.

11. Additional information pertinent to the study is given in the appendices as follows:

Appendix A:	Description of Optronics Film Reader/Writer
Appendix B:	Instructions for Reading Map Coordinates
Appendix C:	Development of the Film-Filter Matrices
Appendix D:	State Laws Affecting Permit Actions in the Coastal Areas Within the Mobile District
Appendix E:	Photointerpreters' Catalog of Regulated Activities*

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Appendix E, the photointerpreters' catalog, can be used independently of this report as a guide to familiarize new photointerpreters with the types of activities and structures most frequently occurring in the Mobile District.

PART II: SELECTION OF A DEMONSTRATION AREA

12. It was recognized that the cost for remotely sensed data made it infeasible to acquire research data for the entire Mobile District. Therefore, a sample area within the District had to be selected for the application and testing of developed procedures. The sample area chosen would have to reflect the permit processing trends of the entire District while at the same time would be small enough to keep down costs.

13. To assist in the location of a satisfactory test area, the WES made a detailed examination of the work load of the Mobile District permit program. The WES arranged with the Mobile District to begin receiving all mailings of permits and public notices, thus allowing for an analysis of trends to be made. A reference collection of these documents covers 1976 and 1977. During this period, nearly 1500 permits in various categories were received.

14. For the WES to determine the recent yearly trends in permits issued by the Mobile District, the monthly summary lists of permits processed were examined for the period 1976-1977. Figure 1 summarizes the number of permits issued monthly during the study period. The categories of permits included in the figure were general, regular, letter, after-the-fact, revision-of-plants, and extension-of-time. Permit-related actions such as cancellations, cease-and-desist orders, revocations, etc., were not included in the summary.

15. It was also necessary to identify the various types of permit activities and determine their frequency of occurrence. Table 1 presents such a list of activities. Each activity was classified into one of six groups: bank and shore protection structures, waterborne commerce and recreation structures, ground surface transportation structures, energy supply and utility-related structures, discharge and intake structures, and other construction and engineering activities.

16. Table 2 summarizes the frequency of occurrence of each permit group during the study period. It can easily be determined from Table 2 that about 70 percent of the total number of regular, general, letter,

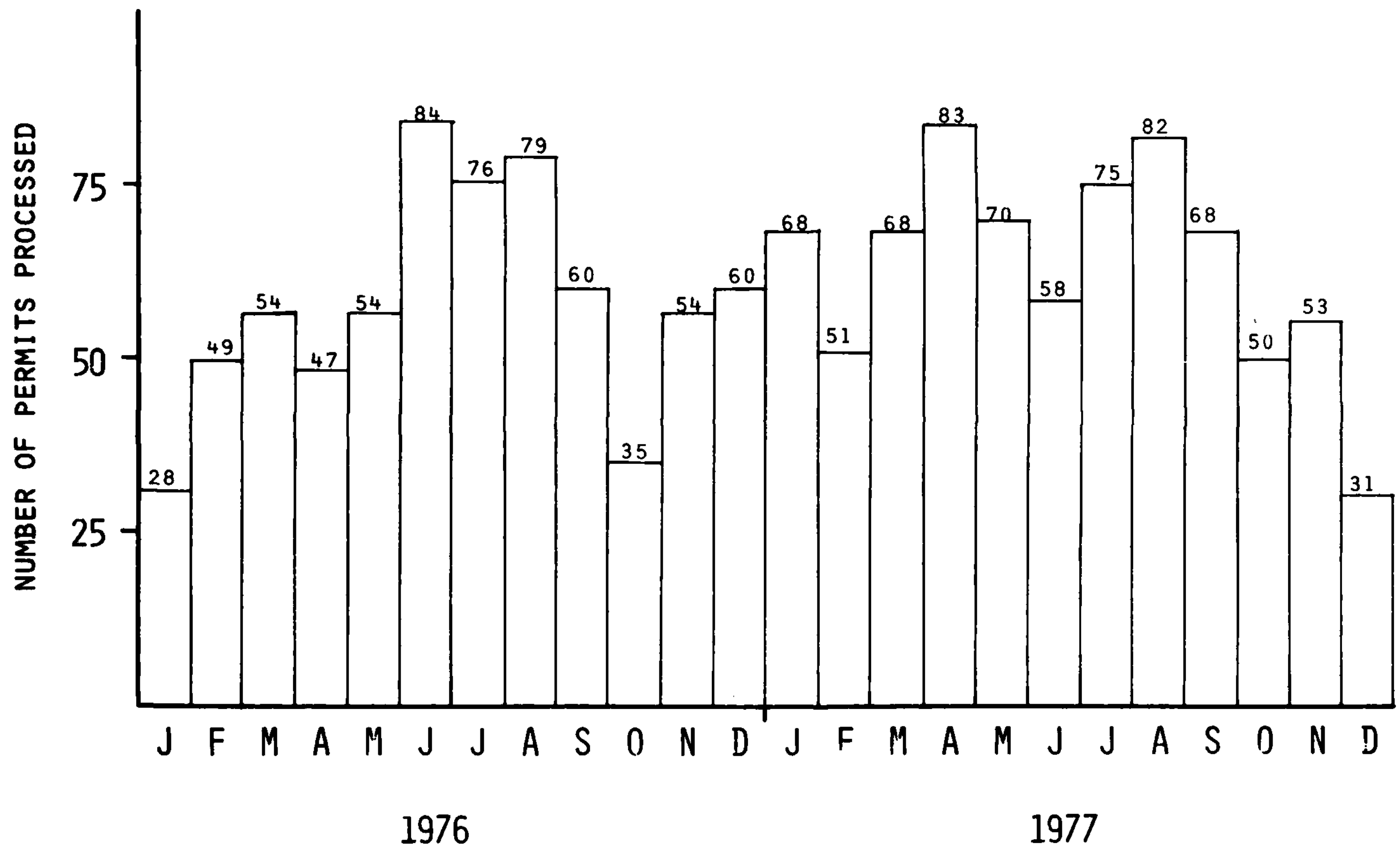


Figure 1. Summary of permits processed by Mobile District

and after-the-fact permits were for activities that could be located in a zone along the Gulf Coast that extends inland only 9 to 12 miles. This also implies that the vast majority of the land area included in the District accounts for only a small part (approximately 30 percent of the permits issued) of the total work effort of the Regulatory Functions Branch.

17. Further examination of the permits, mailing lists, and mapped permit distributions indicated that a large number of permitted activities occurred in the coastal area extending from the southern edge of Bon Secour Bay, Alabama, to the southeastern side of East Bay near Pensacola, Florida (Figure 2). In addition, this area possessed an unusually large proportion of activities in the important Group 2 category (recreational and commercial). The only exception to this coastal area being an ideal representation of the overall District permit program effort was the fact that a large number of Group 3 activities (surface transportation) that are found occurring more frequently in the noncoastal parts of the District were not found in the area.

18. With the coastal area providing a wealth of information for the study of a monitoring and surveillance problem and the Bon Secour Bay to Pensacola coast in particular showing a great diversity of structure types, the WES decided to select that area as the one from which to obtain the three types of remotely sensed data mentioned previously. The magnetic tapes and imagery thus obtained were used to develop information on spectral signatures (reflectance characteristics of materials) and to photographically document many of the activities included in a photointerpreters' catalog (Appendix E).

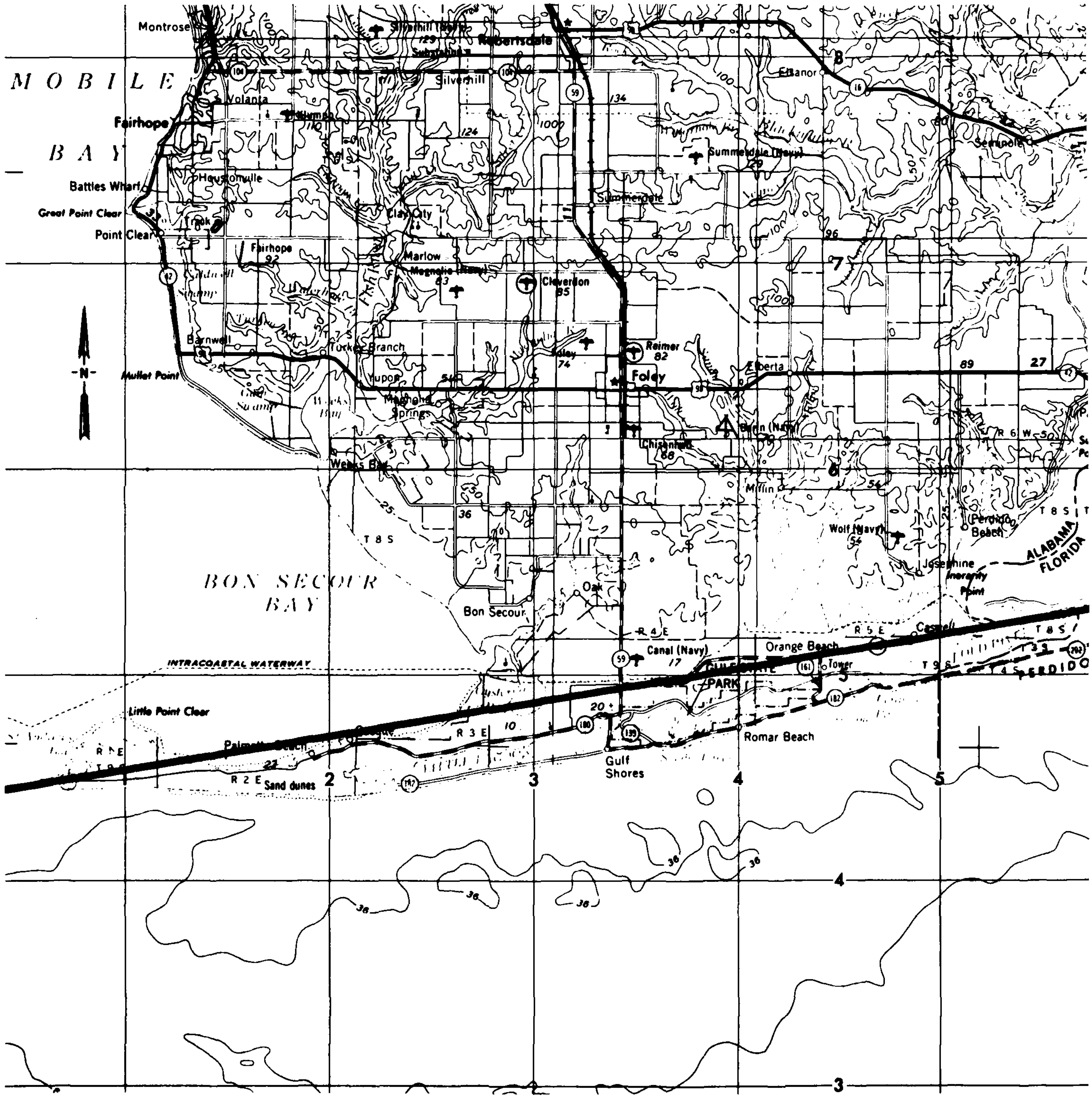
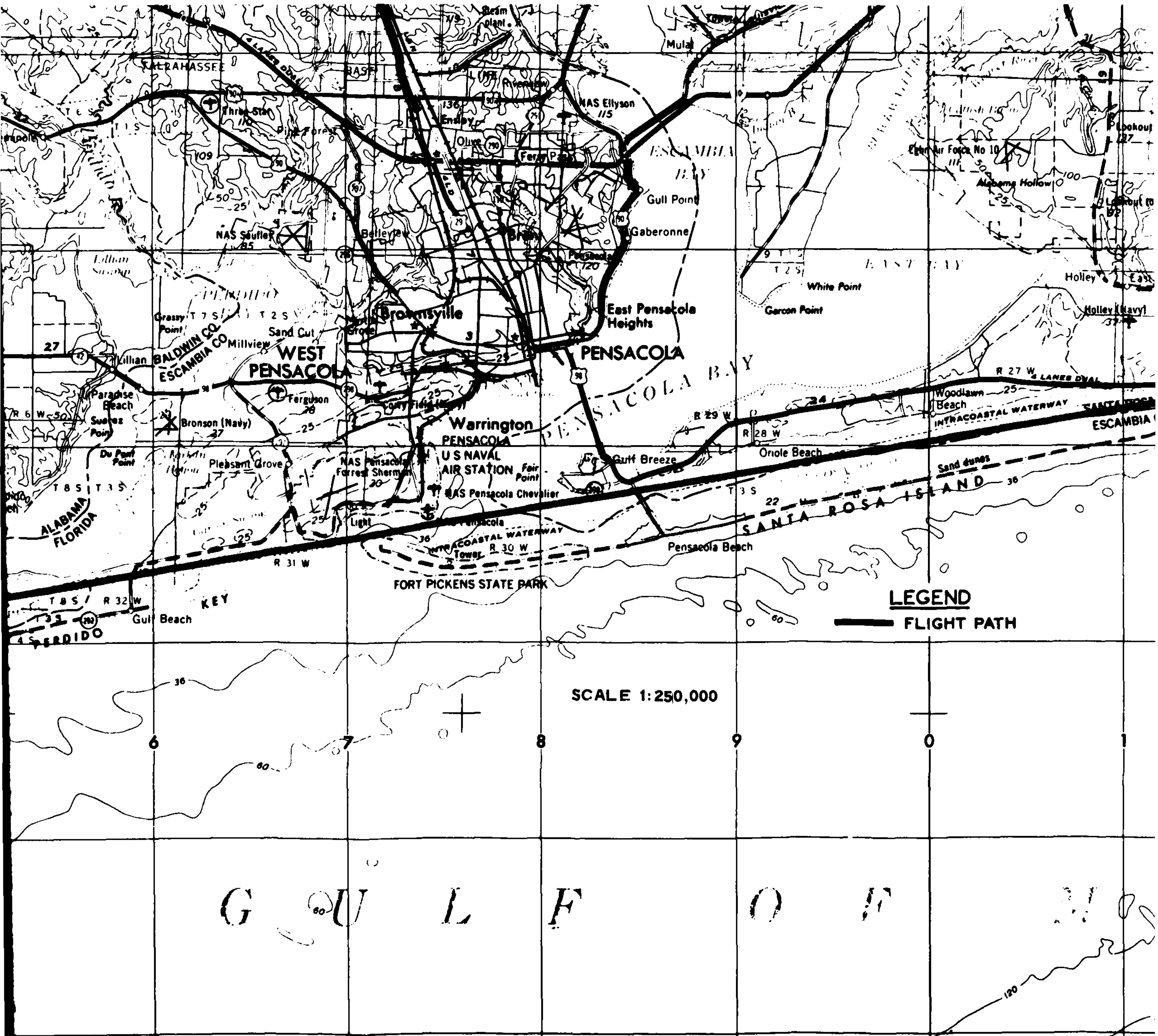
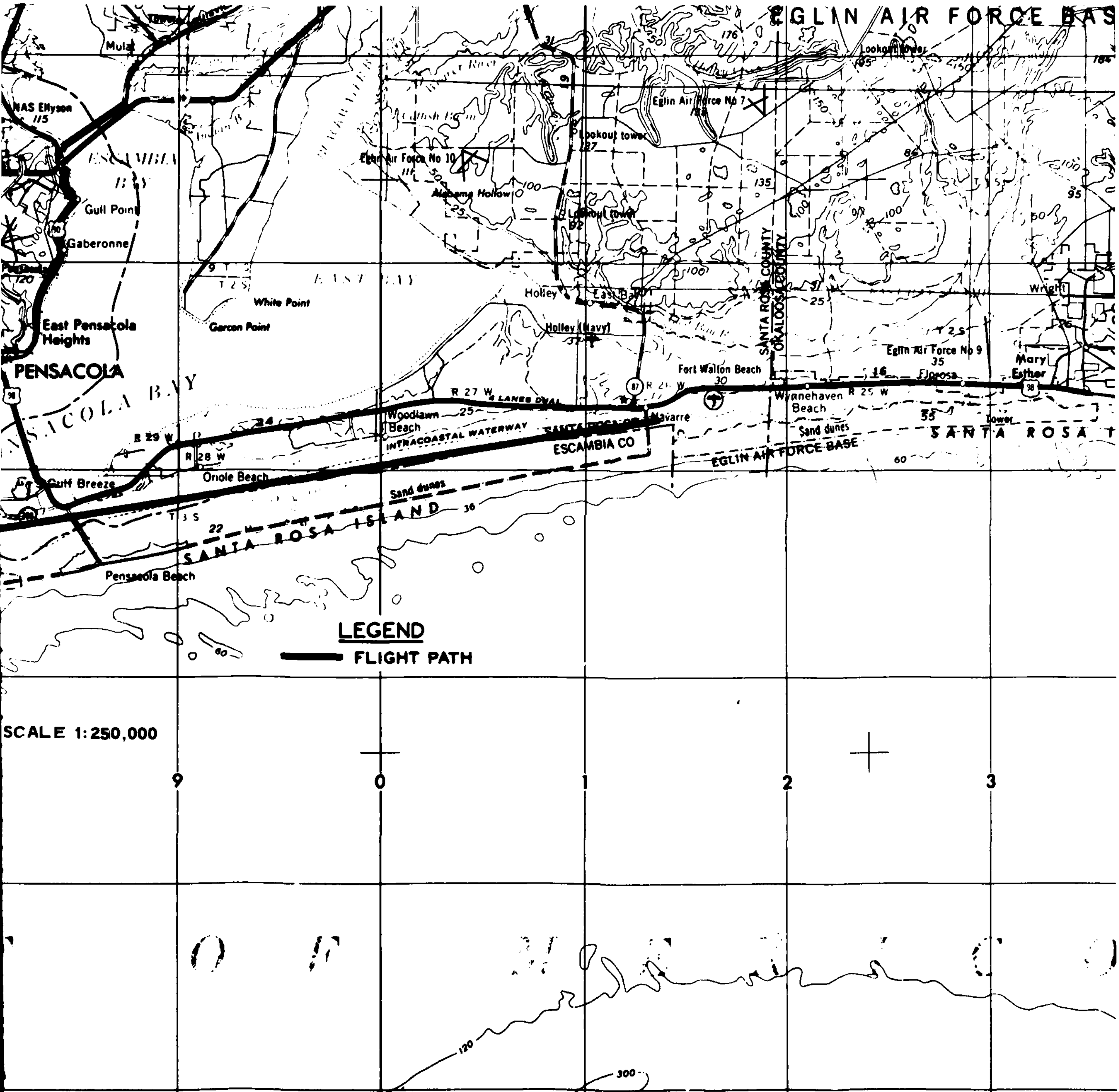


Figure 2. Gulf Coast area most representa



epresentative of permitted activities in Mobile District (Source: USGS 1:250,000 Pensacola, Florida, map)



ct (Source: USGS 1:250,000 Pensacola, Florida, map)

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PART III: DIGITAL SCANNER SYSTEMS

19. A scanner is a sensor system that produces a continuous strip image of the earth in various spectral bands. Carried aloft on an aircraft or satellite platform, the scanner continually scans the earth in swaths perpendicular to the direction of motion of the platform. Scanning is accomplished in the crosstrack direction by an oscillating or rotating mirror. The motion of the mirror causes each scan line to be segmented into a series of separate rectangular picture elements commonly referred to as pixels. The size of each pixel is a function of the instantaneous field of view, the height of the platform above the terrain, and the viewing angle. During the present study, two such scanner systems were investigated: the Landsat MSS and the NASA MMS. These two scanner systems are discussed in the following paragraphs.

Landsat Multispectral Scanner

System description

20. In 1978 there were two active Landsat satellites (Landsat 2 and 3) in orbit around the earth (Landsat 1 was permanently deactivated in January of 1978). Each satellite circles the earth in a near-polar orbit every 103 minutes at an altitude of 569.8 miles. The orbits are arranged so that each satellite passes over a fixed point on the earth's surface every 18 days. The orbits are phased, however, so that one satellite follows the other by 9 days. Thus, virtually every point on the earth's surface is scanned every 9 days.

21. The Landsat MSS scans the earth's surface making radiance measurements of the reflected light from each terrain pixel. The measurements are made in four spectral bands (five in the case of Landsat 3). The spectral response of these bands is as follows:

Band	Spectral Response, μm
4	0.5-0.6
5	0.6-0.7
6	0.7-0.8
7	0.8-1.1
8	10.4-12.6 (Landsat 3 only)

Note: Bands 1, 2, and 3 do not appear in this listing since they were assigned to the three detectors of the Return Beam Videcon (RBV) System. The RBV is another subsystem of the Landsat satellite and is flown simultaneously with the MSS. This subsystem was not selected for examination in this study.

22. The process of data detection and collection is schematically represented in Figure 3. The MSS divides each scan line into rectangular pixels. The pixels are nominally 62 yd wide by 86 yd long and represent roughly 1.1 acres of area. The length dimension of each pixel is approximately parallel to the flight path of the satellite. Reflected radiation from a terrain pixel is received at the satellite as a continuous spectrum and is then divided into four bands (five for Landsat 3). Each band is electronically integrated into a single intensity or radiance value. The four radiance values are then transmitted sequentially to an earth receiving station where they are recorded on high density tapes. This process is repeated over and over again, pixel by pixel and scan line by scan line, as the scanner moves downtrack.

Data processing

23. Landsat MSS data can be acquired from the Earth Resources Observation Systems (EROS) Data Center.* Two principal forms of data are available--image and digital data.

24. Image data or pictures can be produced in several standard nominal scales and product formats. These standard image products can be produced in either black and white or color. Prices of available standard image products are shown in Table 3. Once imagery is obtained from the EROS Data Center, the analysis of the data must proceed along

* U. S. Department of the Interior, Geological Survey, EROS Data Center, Sioux Falls, South Dakota 57198.

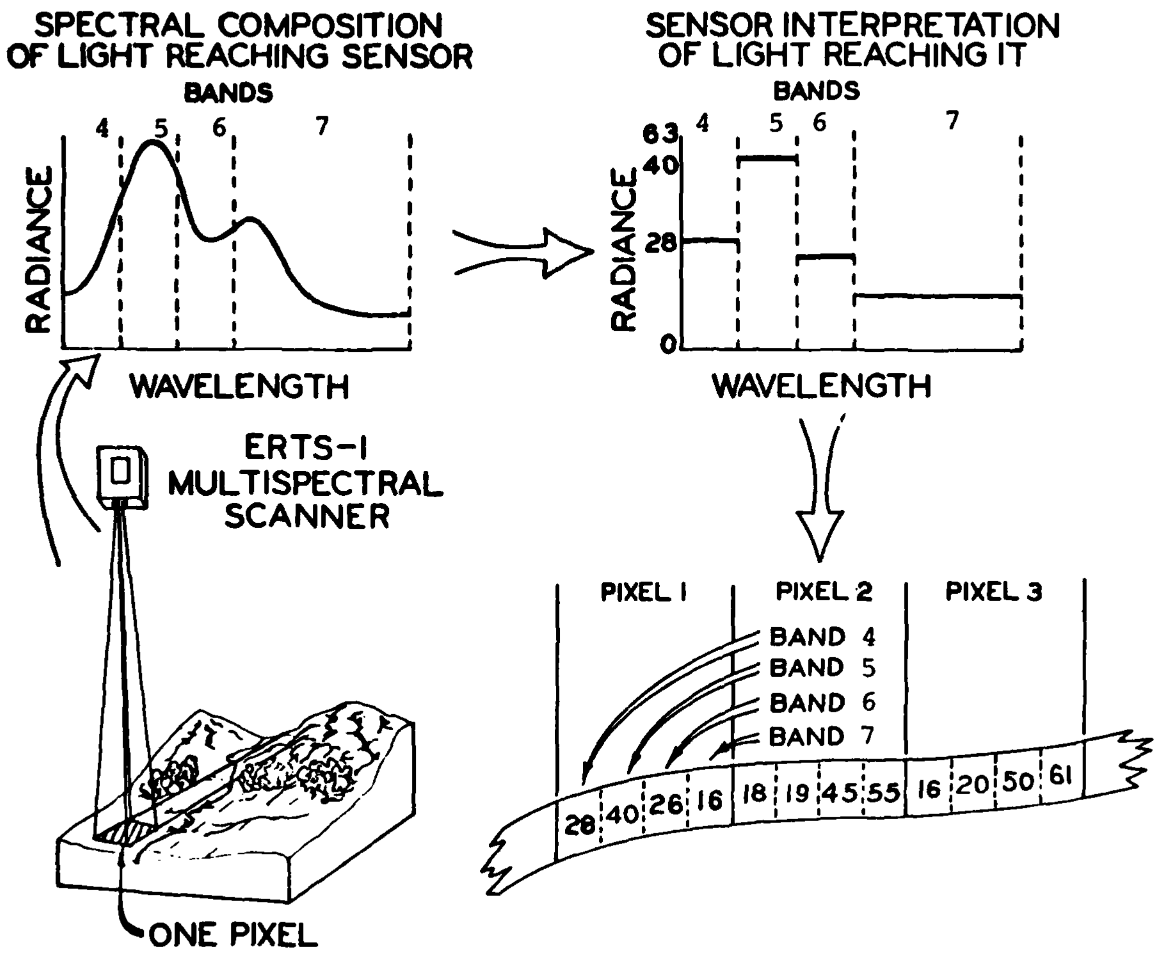

Figure 3. Schematic representation of Landsat data detection and collection

the lines of traditional photointerpretation. Implicit in this type of analysis is a great deal of subjectivity and manual labor.

25. To apply objective and automated procedures, the data must be acquired in nearly its original digital form. In this form, the data have been reformatted from the high-density digital tapes into low-density computer compatible tapes (CCT's) for use by computers. These tapes can also be acquired from the EROS Data Center and their price is shown in Table 3. Analysis of digital data, then, can proceed by more automated and objective techniques utilizing computer-programmed logic.

26. Over the past 5 to 6 years, the WES has developed a capability to process digital data.[1-5] Over 30 different computer programs have been developed that provide the capability to perform the following listed operations on digital image data.

- a. Demultiplex multiband CCT's.
- b. Convert radiance counts recorded on Landsat CCT's to radiance values in mW/cm^2-sr.
- c. Perform statistical analysis of pixel values in terms of radiance count and radiance or optical density values and display the results as (1) tabular lists in columnar form, (2) number arrays printed at location on page determined by pixel location in the data array, (3) x-y plots, and (4) bar graphs.
- d. Produce histograms.
- e. Calculate latitude and longitude of any point (pixel) in an array of pixels defining a Landsat scene or portion(s) thereof.
- f. Calculate centroid of any feature of interest appearing in a digitized image.
- g. Estimate feature size.
- h. Generate tabular listings of the latitude and longitude of the center point of water bodies and the estimated size of each.
- i. Merge CCT data for images of two or more adjacent geographic areas to produce an image of the entire area free of match lines.
- j. Extract radiance values from CCT data for each of the four Landsat spectral bands. Match spectral signatures comprised of the four-band data with one of a set of reference spectral signatures.

k. Rectify data to achieve geometric accordance with a map or another image.

l. Digitally overlay images and detect time-related changes that have occurred.

m. Filter digitized image data to reduce "noise."

n. Correct distortions due to spacecraft attitude and earth's rotation.

o. Digitally enlarge or reduce a selected portion(s) of a digitized image.

p. Produce land-use maps from Landsat data.

q. Produce color separation negatives or positives for purposes of making color composite images of Landsat scenes or multicolor thematic maps.

These programs provide capability to rapidly analyze sequentially obtained scanner data for the detection of change in the landscape and present the results in a black-and-white picture or a color composite picture. These are produced on the Optronics film reader/writer (Appendix A).

Acquisition of Landsat products

27. The usefulness of Landsat data for the detection and monitoring of activities in the Mobile District depends primarily on two attributes of the target activity. The first and most important of these attributes is the size limitation imposed by the size of a pixel. Detection may be possible with just one pixel but to determine shapes requires many more pixels. To roughly determine the shape of an activity usually requires a minimum of 10 to 20 pixels. And this depends to a great extent on the actual shape of the target activity.

28. The second attribute upon which the detection of an activity depends is the factor of contrast. Does the reflectance signature of the target activity differ by a sufficient amount from its background to be detected? Generally this question can be answered affirmatively if the contrast index (see paragraph 123) is great enough to be detected by the human eye on Kodak Aerochrome Infrared 2443 using a Wratten filter number 12. A reference to the film-filter matrices (Appendix C) will provide the user with possible feature-background combinations for which contrast indices have been determined.

29. If the size and contrast index of an activity are determined suitable for detecting and monitoring purposes by Landsat, then a review of available Landsat Coverage can be made through the EROS Applications Facility* or the EROS Data Center. A computer search of coverage for a point or an area can be made. To initiate a point search, the latitude and longitude of the point in question must be provided. To initiate an area search, the locations of each corner of a rectangle encompassing the area of interest must be provided.

30. Also, a preferred time of year, a minimum acceptable scene quality rating, and the maximum percent cloud cover acceptable must be specified to the computer. A scene quality rating of 5 or greater is usually adequate. The maximum cloud cover acceptable depends on the extent of the area under investigation. If the area is quite large (i.e., extends over one quarter or more of the scene), a maximum cloud cover of 10 percent is probably tolerable. If the area is small (i.e., 4 or 5 square miles), a maximum cloud cover of 30 percent will probably suffice. The solution to the problem of cloud cover interference is to order the 1:1,000,000 scale imagery of Band 5 (Product Code 23) and determine exact cloud locations before ordering other products.

31. Scale requirements of products ordered depend on the application for which the imagery is intended. Again, size of the activity to be detected is the dominant consideration. Since most activities in the Mobile District, including dredging and filling operations, do not extend over areas much larger than 40 to 60 acres, a general rule for scale would be to use the largest scale available. This would mean usually ordering a scale of 1:250,000. Larger scales can be produced by using Landsat digital data but these also have their limitations. The WES has produced useful images at a scale of 1:50,000. However, at this scale individual pixels are very apparent and the overall appearance is blocky. Even so, many features (e.g. water bodies, cleared areas, and forested lands) are discernible in the imagery.

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* EROS Applications Facility, NSTL, U. S. Geological Survey, Bay St. Louis, Mississippi 39520.

Detection and monitoring
using Landsat data

32. As previously described, the Landsat MSS remotely senses energy reflected from the earth in four different ranges (five for Landsat 3) of the electromagnetic spectrum. The radiation sensed by the scanner varies with the characteristics of the reflecting body as to wavelength and intensity, but all spectral returns are converted into digital values in their respective bands. When these digital values are reproduced as imagery, each band presents its own unique picture of the same scene. Further, certain objects in a scene may yield more information about themselves in one spectral band than in another. With this background, Table 4 was taken from a chart prepared by NASA[6] to aid users in selecting the band that will probably be most helpful t them in their particular area of study. The chart represents a consensus of the findings and opinions of various users of Landsat data. In cases where more than one band is listed, investigators found that more bands were especially useful.

33. Within the scope of work usually performed by the Mobile District, Landsat data can probably best be applied as a tool for change detection. Detection of changes that occur as a result of the depositing of fill material within coastal wetlands is one example. The large contrast values that occur between the high reflectance values of the fill material and the low reflectance values of water and marsh vegetation make this particular circumstance very easy to detect. This is true, of course, provided that sufficient area has been affected by the fill operation (i.e., approximately 10 acres or greater).

34. Another application of Landsat data is the determination of water-land boundaries. Since incident light in Band 7 is so readily absorbed by water, water-land interfaces are easily detected. This application is discussed further in Part V of this report.

35. Some researchers have met with a great deal of success in detecting wetland boundaries, major vegetation associations, and wetland types from Landsat color composite imagery.[7] Their use of the data requires photointerpretation skills. By using a combination of imagery

at a scale of 1:250,000 obtained at different times of the year together with a Bausch and Lomb Zoom Transfer Scope (ZTS), wetland maps were compiled that depicted three categories of marsh:

a. Salt marsh containing predominantly *Spartina alterniflora* (saltmarsh cordgrass)

b. Near-saline to brackish marsh containing predominantly *Juncus roemarianus*.

c. Brackish to fresh marsh containing large stands of *Spartina cynosuroides* along stream margins and *Scirpus americanus* or *S. olneyi* (three-squares) or *Juncus roemarianus* often filling in the remaining area.

Modular Multispectral Scanner

System description

36. The MMS is very similar in principle to the Landsat MSS. However, two primary differences set it apart from the MSS. First, the number of bands into which it quantizes the spectrum of reflected radiation is eleven instead of four. Second, the altitude from which the MMS can be operated is not fixed as it is in the case of Landsat. The MMS platform is usually flown in an aircraft as shown in Figure 4. This gives the investigator great flexibility for selecting the size of the resolution element of the scanner (i.e., the size of an MMS pixel can be specified by the investigator in effect by choosing the proper altitude (Table 5)).

37. One detrimental aspect of the scanner is its varying pixel size within a single scan line. As the scanner sweeps through its total field of view (115 deg), the pixel size changes as a function of the distance from the aircraft's nadir point (Table 5). This phenomenon produces distortion at the edges of images. The distortions can be removed, however, by performing a slight stretching operation on each scan line as it is printed into picture form.

38. The spectral responses of the 11 bands of the MMS are as follows:

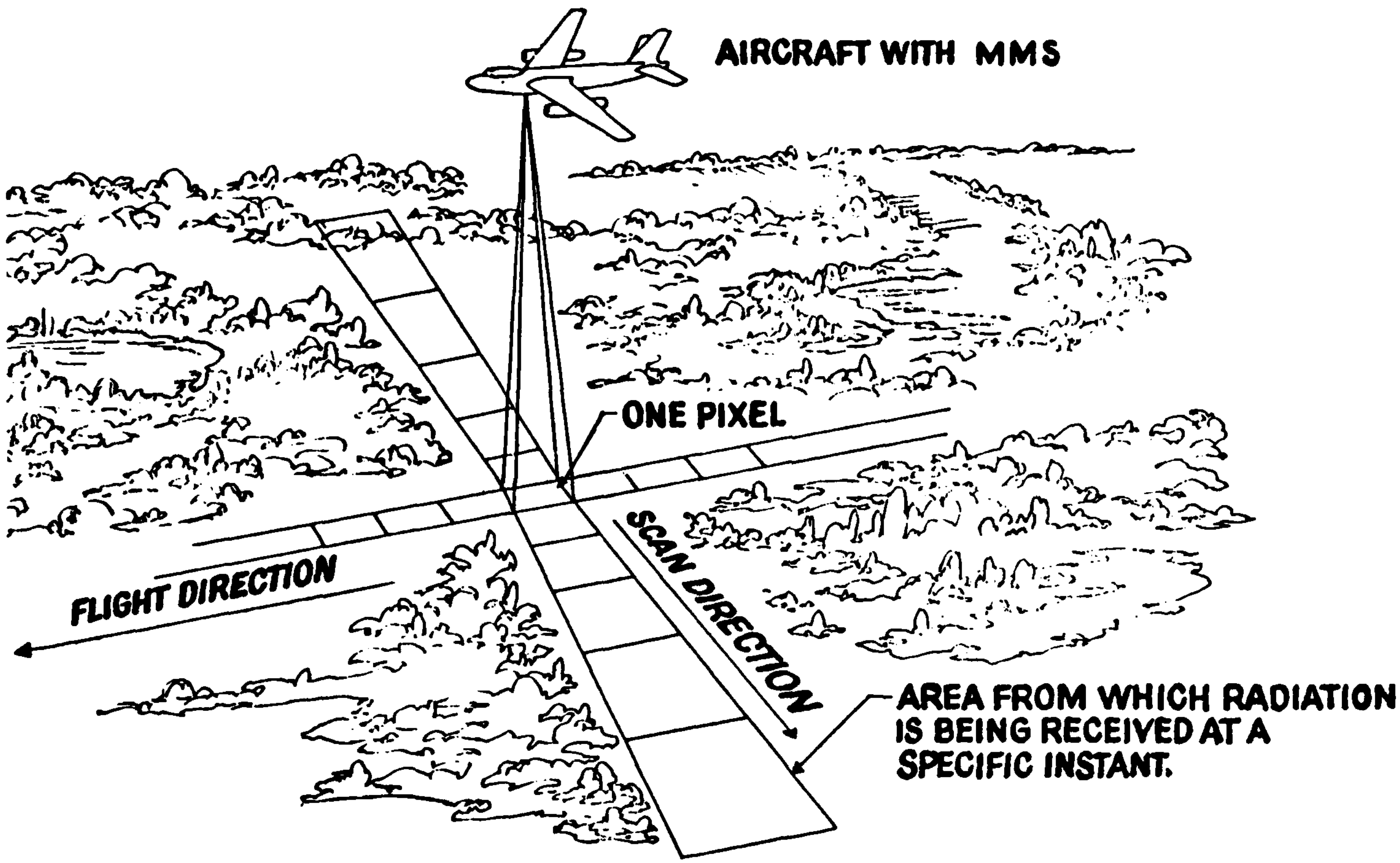

Figure 4. Schematic diagram showing relationship of scan and flight direction of the MMS

Band	Spectral Response, μm
1	0.380-0.440
2	0.440-0.490
3	0.495-0.535
4	0.540-0.580
5	0.580-0.620
6	0.620-0.660
7	0.660-0.700
8	0.700-0.740
9	0.760-0.860
10	0.975-1.055
11	8.000-14.000

Data processing

39. Unlike the several Landsat standard products available from the EROS Data Center, the Johnson Space Center (JSC)* provides the user with CCT's only. This of course necessitates the use of a computer and computer programs in all subsequent processing of the data.

40. During the present study, the WES developed several computer programs to process MMS data. The capabilities of these programs permit the performance of the following listed operations on the digital data.

- a. Demultiplex multiband CCT data.
- b. Extract n by m arrays of radiance values from CCT's.
- c. Perform statistical analysis on extracted data arrays.
- d. Generate tabular listings of data arrays.
- e. Correct distortion due to varying pixel size as a function of viewing angle.
- f. Digitally enlarge or reduce a selected portion of the CCT's.
- g. Produce color separation negatives or positives for purposes of making color composite images or multicolor thematic maps.

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* National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Texas 77058.

Cost of imagery produced
from the MMS data

41. The costs of imagery produced from the MMS data are presented in Table 6. These costs include the cost of acquiring the raw data as well as those expenses incurred by the WES to process the data into final images. Note that these costs do not include any processing costs to remove distortions. The addition of distortion removal to the processing procedure would increase the cost by approximately 30 percent.

Detection and monitoring
using MMS data

42. For assessing the capability of the MMS data to detect regulated activities occurring along the coastal regions of the Mobile District, the WES requested that the JSC fly an MMS mission on a course over the coast from the southern edge of Bon Secour Bay, Alabama, to the southeastern side of East Bay near Pensacola, Florida, which was the flight path selected for acquisition of remote-sensing data for this study (see Figure 2). Flights were conducted over the same course at four altitudes - 2,000, 4,000, 7,000, and 12,000 ft.* In addition to the MMS data, color infrared (IR) photography was simultaneously taken for comparison purposes.

43. After receiving the color photography and CCT's from the JSC, the color imagery was examined closely and a site was selected for extensive study. Terry Cove, Alabama (Figure 5), was selected as that site since it contained many Corps-regulated activities. Three investigations utilizing the MMS digital data were conducted on Terry Cove.

44. The first investigation was conducted simply to determine what information was available in each of the 11 bands of data. Black-and-white pictures (Figures 6-16) were generated for each band of the 2000-ft data to assist the investigation. The capability of each band to detect various features is summarized in Table 7.

* Variables pertaining to aerial photography (i.e., focal length, film dimensions, altitude, etc.) have been expressed throughout this report in U. S. customary rather than metric units since they are preferred by the Mobile District.

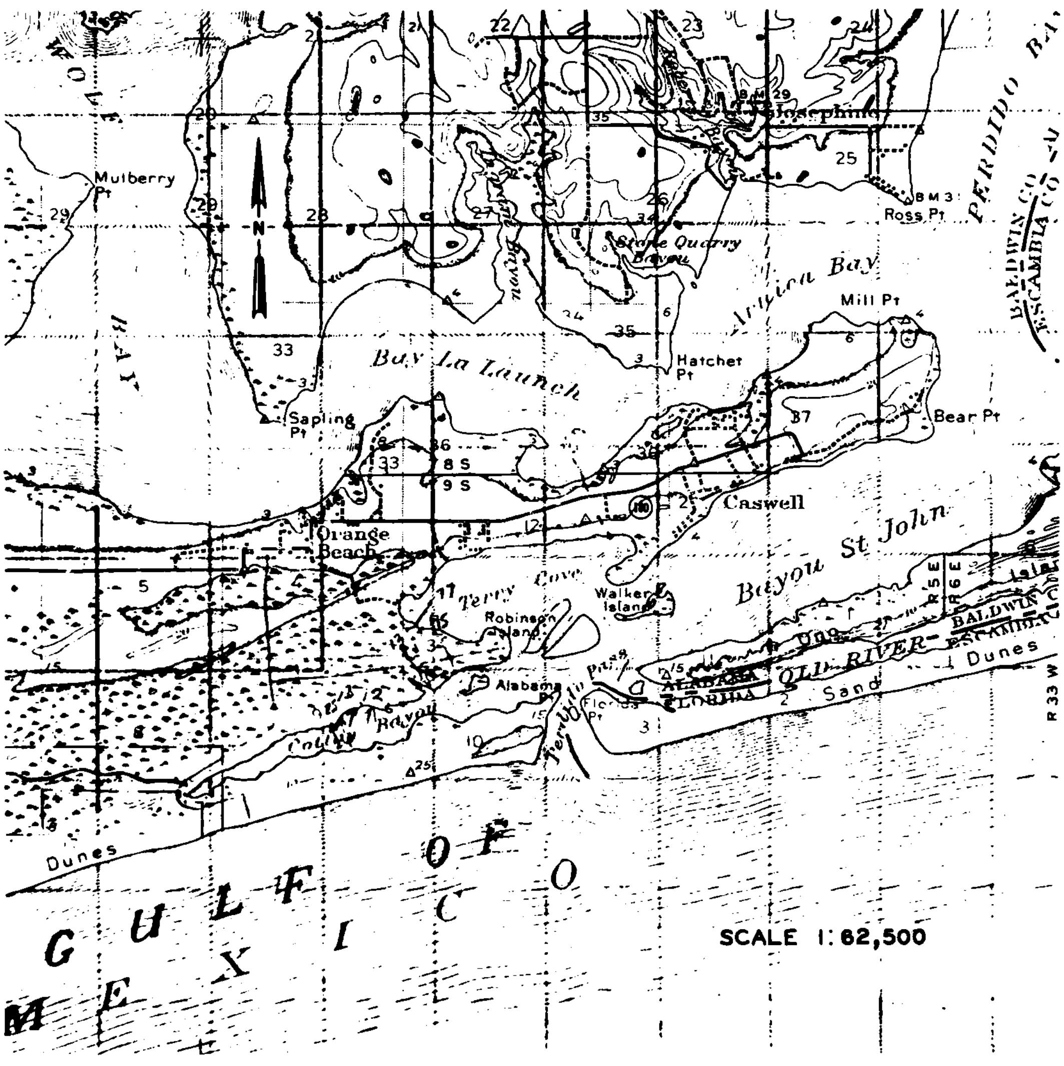


Figure 5. Topographic map of Terry Cove, Alabama, and surrounding area (Source: USGS 1:62,500 Foley 15-minute Quadrangle)

Figure 6. Band 1 image of Terry Cove using the 2000-ft MMS data

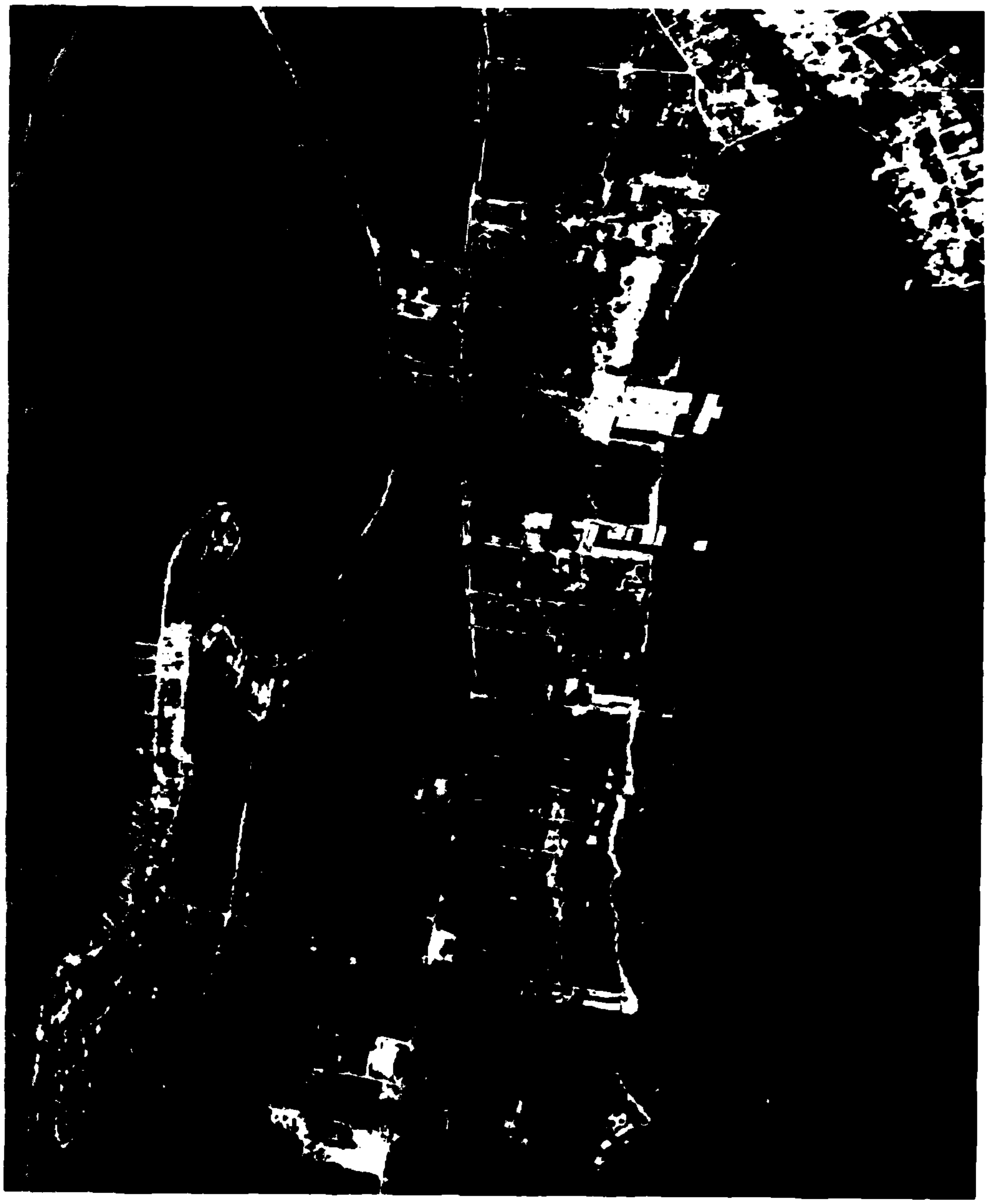


Figure 7. Band 2 image of Terry Cove using the 2000-ft MMS data

Figure 8. Band 3 image of Terry Cove using the 2000-ft MMS data

Figure 9. Band 4 image of Terry Cove using the 2000-ft MMS data

Figure 10. Band 5 image of Terry Cove using the 2000-ft MMS data

Figure 11. Band 6 image of Terry Cove using the 2000-ft MMS data

Figure 12. Band 7 image of Terry Cove using the 2000-ft MMS data

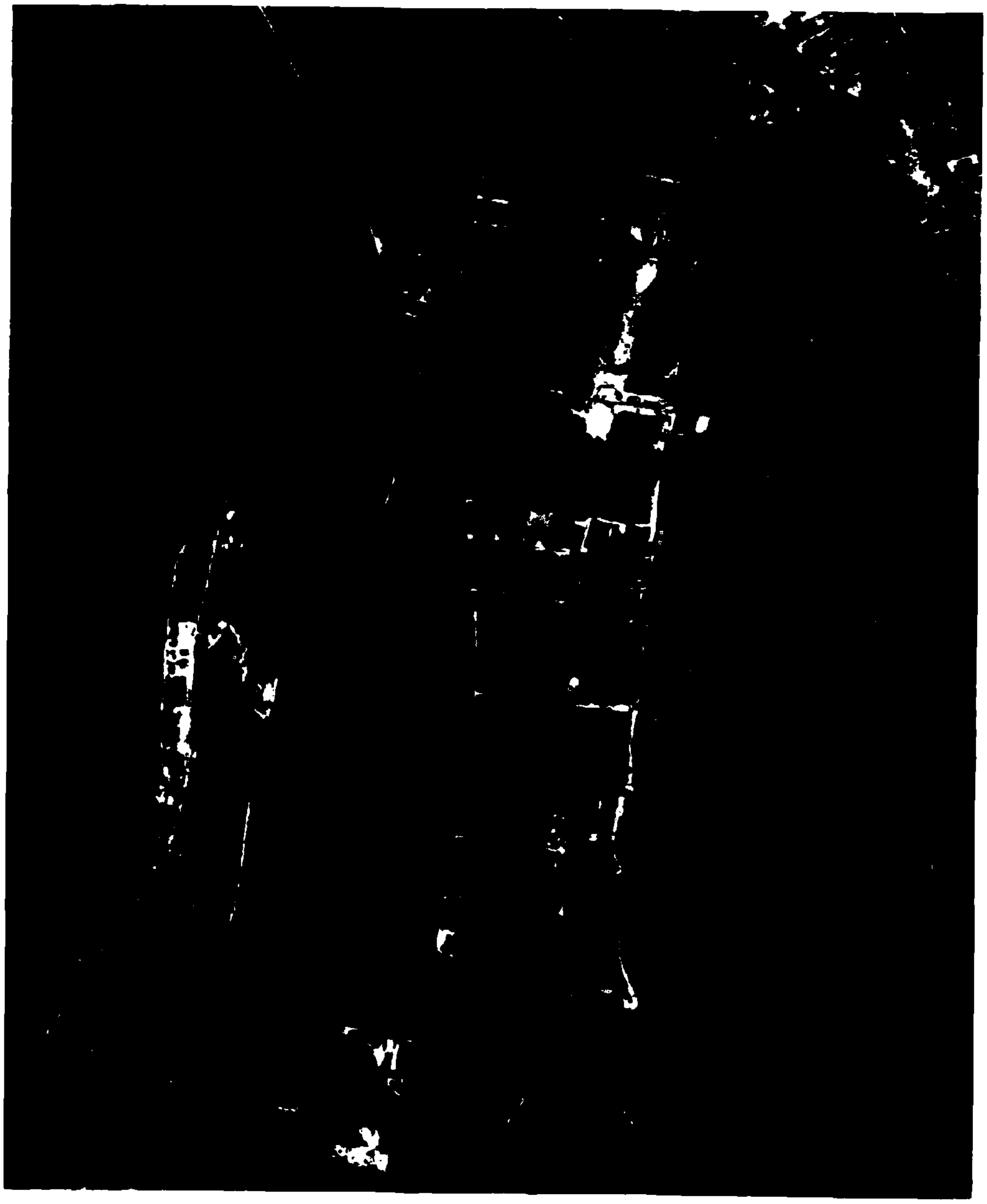


Figure 13. Band 8 image of Terry Cove using the 2000-ft MMS data

Figure 14. Band 9 image of Terry Cove using the 2000-ft MMS data

Figure 15. Band 10 image of Terry Cove using the 2000-ft MMS data

Figure 16. Band 11 image of Terry Cove using the 2000-ft MMS data

45. The second investigation was conducted to determine the resolution capabilities of the data as a function of altitude. Using Band 9, four pictures were produced, one each at the four different altitudes (Figures 17-20). At each altitude above 2000 ft, the imagery was digitally enlarged to the same scale as the 2000-ft altitude. The capabilities of the MMS to detect various features at the different altitudes are indicated in Table 8.

46. The third investigation was made to determine the data bands that could be used to generate color composites that duplicated the spectral sensitivity of the color IR photography. Color photography often has clear advantages over black and white when used by photointerpreters to determine changes in vegetation by detecting tonal variations in the photography. Thus, if the MMS imagery can be made to duplicate the information content of color IR, information can be more readily obtained from the MMS imagery by photointerpreters.

47. It was determined in this investigation that color composites duplicating color IR imagery could be produced by using Bands 4, 6, and 9. The colors yellow, magenta, and cyan were assigned to these three bands, respectively, and the composite picture shown in Figure 21 was produced. By comparing this product with the color IR shown in Figure 22, one can see the numerous similarities between the two.

Comparison of Systems

48. The advantages to the Mobile District using digital MMS data are as follows:

- a. Automated classification and interpretation.
- b. Variable pixel size with altitude.
- c. Digital enhancement of imagery.

49. Traditional methods of land-use classification by photointerpretation techniques require many subjective decisions throughout the manual classification and mapping procedures. This usually requires many man-hours of labor and is subject to frequent errors. Still further, the work cannot be exactly repeated by another photointerpreter or even

Figure 17. MMS Band 9 image of Terry Cove from 2000 ft

Figure 18. Digital enlargement of the 4000-ft MMS Band 9 image of Terry Cove

Figure 19. Digital enlargement of the 7000-ft MMS Band 9 image of Terry Cove

Figure 20. Digital enlargement of the 12,000-ft MMS Band 9 image of Terry Cove

Figure 21. Color composite picture of Terry Cove produced by superimposing MMS Bands 4, 6, and 9

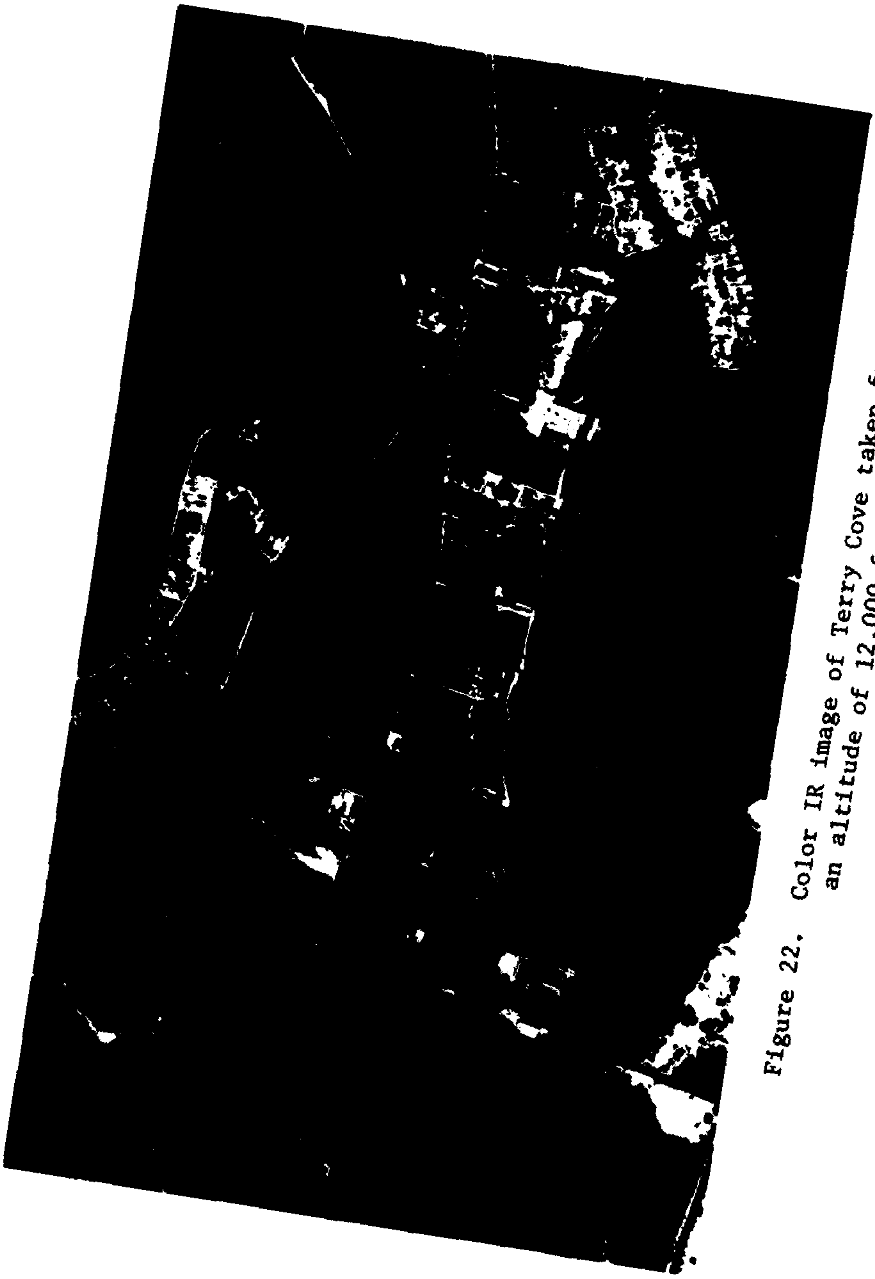


Figure 22. Color IR image of Terry Cove taken from an altitude of 12,000 ft

by the initial photointerpreter himself. However, given the classification thresholds for each channel, the digital MMS data can be automatically classified using a computer. This method of classification is highly repeatable since the subjective decisionmaking processes of the photointerpreter are replaced by the objective programmed logic of the computer.

50. One advantage digital MMS data has over MSS data is the variability of pixel size. Thus, by choosing various altitudes, the user can control the resolution of the output images. The trade-off in this circumstance is decreased scanned area; that is, to gain high digital resolution, one must sacrifice large scanned areas. This can or cannot be a problem depending on the locations and distribution of the activities of interest.

51. Another advantage digital data have over photographic data is the capability of selective image enhancement. Depending on the actual reflectance values of the feature of interest, the computer can selectively enhance these values to increase their contrast in the output imagery. Thus, if a feature has a reflectance signature differing by only two or three radiance values from its surrounding background, the computer can automatically assign darker or lighter gray tones to these values to make the feature contrast highly against its background.

52. The requirement that digital data be processed by computers is probably a disadvantage to the Mobile District. The problem is that to gain maximum effectiveness from digital data would require ready access to a computer and digital image-processing equipment. It would also require specialized personnel for processing the data into forms useable with current data-handling techniques of the Mobile District.

PART IV: AERIAL PHOTOGRAPHIC SYSTEMS

53. The growing need for rapidly acquired information in such areas as environmental management, energy studies, ecological studies, engineering and mapping surveys, intelligence gathering, etc., has produced a technical field with an expanding role for remote-sensing applications to many Corps District functions. Aerial photographic systems of several types are readily available and provide one of the most efficient and commonly used means for the acquisition of large quantities of remotely sensed data. The major categories of aerial photographic documentation used today include panchromatic, color, color IR, black-and-white IR, and multispectral imagery.

54. Within this part of the report, procedures for detecting and monitoring using aerial photographic systems shall be discussed with a primary emphasis placed upon acquisition of information of the type that will aid personnel of the Mobile District in the planning and execution of missions utilizing aerial photography. A considerable quantity of data on sources of imagery pertinent to the needs of the Mobile District has been included and should provide a broad base for the tasks of future mission planning for the detection and monitoring of activities associated with the Corps permit program.

Background

Photographic scale

55. The photographic scale of aerial imagery to be utilized in locating and monitoring remotely sensed activities will determine to a large degree what information may be extracted from the imagery. Given controlled flight conditions and the absence of adverse atmospheric factors, the photographic scale and the resolution capability of the film employed will limit the level of detail that can be seen on the final photography.

56. In the simplest terms, photographic scale is the ratio of a distance on a photograph to the same distance occurring on the ground, or

$$\text{Scale} = \frac{\text{photographic distance}}{\text{ground distance}}$$

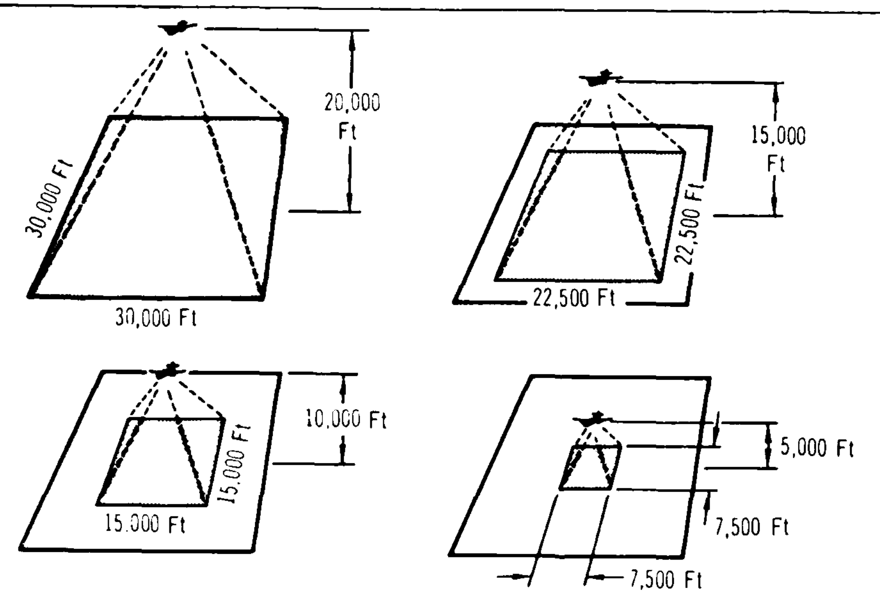
where both distances are given in the same units of measurement. The importance of scale to the imagery being acquired lies in the relationship between the size of the ground area being examined and the size of its image in the photography. The size of an image of a given ground area will vary inversely as the square of the altitude (Figure 23). It is because of the scale-to-area relationship that careful consideration should be given to the type(s) of film to be employed and the scale that will be represented in the final product. A futher discussion of photographic scale is given later as it relates to mission planning (paragraph 114) and to reading map coordinates (Appendix B).

Films

57. Aerial photographic films[8] can be placed in two general categories: (a) black and white and (b) color. These films vary in their spectral, spatial, and energy sensitivity characteristics. They may also be used in a number of formats. Although smaller film sizes are receiving increased attention, a majority of aerial cameras used for remote sensing use a film format of 9 by 9 in.

58. Black-and-white films are the simplest in construction and consist of an emulsion of silver halide grains and gelatin coated on a plastic base material. The silver halide grains range in size from approximately 0.1 to 5 μm. The film is made sensitive to nearly the entire visible spectral region (0.4-0.75 μm) by the use of panchromatic sensitizing dye; hence, many black-and-white films are termed panchromatic films.

59. The use of multiple cameras or multiple-lens cameras to allow the simultaneous exposure of various black-and-white film-filter combinations is termed multispectral photography. These techniques obtain imagery that can be used to better distinguish between selected features on the basis of differences in their reflectance characteristics.



3-in. Focal Length

Figure 23. Effect of altitude on ground coverage

60. Color films are much more complex than black-and-white films. First, they are divided into two basic types: color-reversal films and color-negative films. Both types consist of three emulsions coated on a plastic base. Figure 24 shows the basic structure for most color-reversal films. The antihalation layer prevents the reflection of light from the base back to the emulsions. Above the antihalation layer is the red-sensitive emulsion. This emulsion contains a color-forming agent that forms a cyan dye when coupled with an oxidized color-developing agent. A gel layer separates the red-sensitive emulsion from the green-sensitive emulsion. This layer contains a color-forming agent that produces a magenta dye. The green-sensitive layer is capped with a yellow filter material that prevents blue wavelengths from reaching the first two emulsion layers. The top emulsion layer is blue-sensitive and forms a yellow dye when coupled with the proper color-developing agent. The emulsions are made sensitive to the blue, green, and red portions of the visible spectral region by use of sensitizing dyes similar to those discussed for black-and-white films.

Filters

61. Filters are used to limit the radiation reaching the film to that within a fixed spectral band. The effect of a particular filter on impinging radiation is determined by the filter transmission curve. This curve defines the percentage of the impinging radiation transmitted by the filter as a function of wavelength. The transmitted radiation is equal to the product of the impinging radiation and the percent transmittance. See Figure 25 for an example of a transmission curve.

62. Whenever a filter is used, a significant amount of light may be absorbed, and thus the energy per unit area reaching the film may be reduced. To obtain satisfactory photographs, it is necessary to compensate for this loss by increasing the exposure time (i.e., decreasing the F-stop of the lens). The necessary increase in exposure is, of course, proportional to the amount of light absorbed by a particular filter and is normally given by an index called the filter factor. Filter factors are published for various film-filter combinations. A particular filter may have a different filter factor value for different

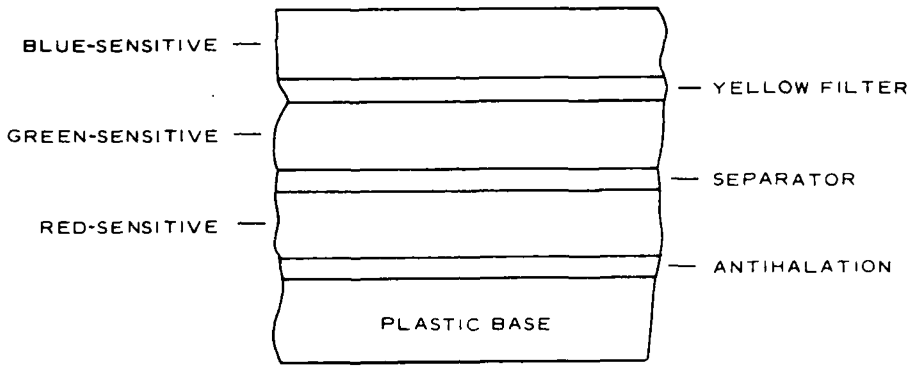


Figure 24. Basic structure of color-reversal films

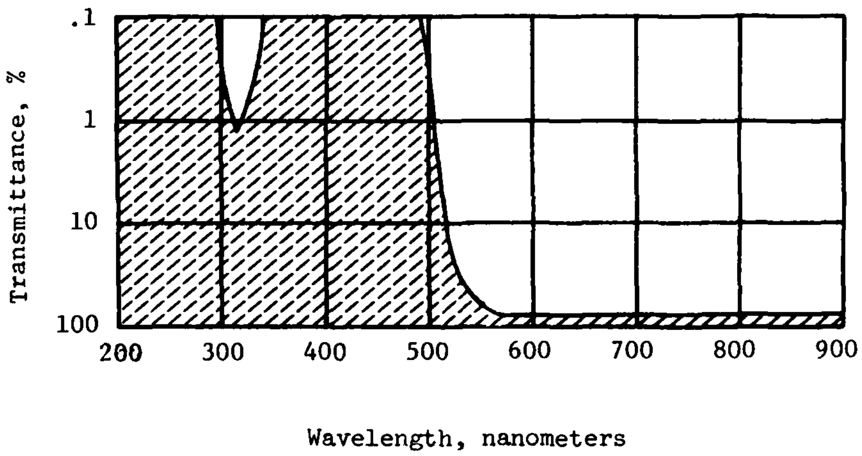


Figure 25. Filter transmission curve for Kodak Wratten Filter No. 12 (medium yellow)

films because of differences in the sensitivities of films. For example, a Wratten 25 filter has a filter factor of 4.0 when used with Kodak Plus-X panchromatic film and a filter factor of 3.0 when used with Kodak Tri-X panchromatic film.

63. The filter factor is used in the following manner to determine the correct exposure settings (time and F-stop) for a particular film-filter combination. The correct exposure time for a given F-stop for the film without the filter can be multiplied by the filter factor to determine the exposure time required for the film-filter combination. Alternatively, the exposure time can be kept constant and the F-stop can be decreased. The correct decrease in F-stop for common filter factors is given in the following tabulation.

Filter factor	1.2	1.5	2	2.5	3	4	5	8	12	16
F-stop decrease	0.33	0.66	1	1.33	1.66	2	2.33	3	3.33	4

Special filters for wide-angle lenses (antivignetting filters), color-compensating filters, and polarizing filters are available for special-purpose application. Because of their limited use, they will not be discussed in this report.

64. One of the major problems that must be overcome if maximum information is to be obtained from any aerial imagery is the production of the greatest image contrast between the background and the activity that is to be detected. To aid mission planners in the selection of the film and filter best suited to produce these results, the WES has developed a computer-based model that predicts contrast between feature and background. The model calculates contrast as a function of the reflectance properties of materials, atmospheric conditions, solar zenith angle, sensor altitude, and sensor characteristics.[8, 9] The contrast values thus obtained allow for an analytical procedure for selection of a film and filter combination that will yield the greatest information about a specific feature type to be examined and monitored in the final imagery. A series of matrices have been generated for several of the most commonly employed aerial films and filters (Appendix C). The use of the matrices in the decisionmaking process of mission

planning will be covered in greater detail at a later point in this part of the report (paragraph 131).

Planning Photographic Missions

65. Once a need for new information has been identified, it becomes necessary that a careful and detailed approach to mission planning be initiated to ensure that time and cost limitations allow the maximum quality and quantity of information to be obtained. The planning and execution of most aerial remote-sensing missions require that six general steps be followed:

a. Mission definition.
b. Review of available coverage.
c. Review of sources from which new imagery can be obtained.
d. Mission specification.
e. Quality control.
f. Processing data into final forms.

66. The application of the six general steps to a logical conclusion will normally result in successful missions that will provide the information necessary to answer, at least partially, the problem that has been identified. The following discussion addresses each of the six general items.

Mission definition

67. The mission definition is a critical prerequisite to the planning stage for aerial photographic missions and establishes the framework within which existing photography is selected or criteria for new photography are formulated. Without this frame of reference, successful mission planning is much less likely to be achieved and unnecessary allotments of time and costs are frequently incurred.

68. The mission definition can generally be developed by a consideration of the following four concepts:

a. Extent of coverage required.
b. Types of activities to be detected.
c. Format requirements of final products.
d. Scale requirements of final products.

Each of these concepts, when fully defined and considered with respect to each other, will point out specific criteria necessary to plan and execute a successful mission oriented toward the use of aerial imagery.

69. Extent of coverage required. Within the limits of the problem that has been identified, an early attempt should be made to clearly and accurately define the precise geographic areas where imagery is needed. A documented statement including geographic coordinates* and related locator references, in conjunction with boundaries that have been drawn on standard maps, will greatly assist mission planners and contractors in assessing the magnitude of the mission to be accomplished. Many Federal agencies engaged in obtaining aerial imagery will require this type of information early in the stages of contract negotiation, and therefore a careful consideration and timely completion of this task will prevent many errors in later planning stages.

70. Types of activities to be detected. A reasonably precise concept of the types of activities to be detected by a proposed mission to obtain aerial imagery will provide considerable guidance to planning personnel. Attention to the nature and configuration of the activity types will often allow for the elimination of many of the standard films and filters or methods of acquiring aerial imagery.

71. Within the Mobile District, nearly 70 percent of the activities covered by the permit program occur along a narrow zone that includes the immediate Gulf Coast or those areas lying generally within 9 to 12 miles from the coast. In this particular case, much of the surveillance performed by the District will involve the selection of films, filters, and flight criteria that allow for the discrimination of activities such as boating facilities (e.g., piers, docks, marinas), shoreline modifications (e.g., dredging, filling, bulkheads, jetties), or activities that may affect coastal wetlands in a manner that violates existing laws. A mission designed to produce information from imagery of coastal features may have many requirements that will differ from

* See Appendix B for instructions for reading map coordinates.

those identified for detecting activities in noncoastal areas. Thus each case must be dealt with separately.

72. Format requirements of final products. A determination of the format requirements of the final products of a remote-sensing mission is an aspect of the mission definition that should be considered in detail well in advance of the actual planning sequence. From the earliest possible time, planners must consider how the imagery obtained will be utilized and how the handling capabilities available to the receiving agency will limit their use.

73. Imagery products commonly used in aerial photographic remote-sensing applications (Table 9) will be mainly in the form of paper or film. In recent years, the imagery has been frequently produced on the polyester bases ("plastic papers"), which are very durable. The imagery may also be obtained as color, color IR, black and white, or black-and-white IR and may be produced as positive or negative images. Film formats include rolls or sheets in various sizes (e.g., 9 by 9 in., 5 by 5 in., 35 mm, etc.).

74. Frequently, special requirements for the indexing and numbering of scenes are necessary along with items such as fiducial marks (reference marks), project designations, photographic scale, flight altitude, etc. Applications may be planned for those photo indices that will be required at specified scales or covering designated ground areas (e.g., equal to 7.5-min, 15-min, or 30-min quadrangle map sheets). The early conceptualization of format requirements necessary to accomplish mission goals and comply with the working limitations of the resources available will often make mission planning more effective and easier to accomplish.

75. Scale requirements of final products. Scale requirements of aerial imagery to be acquired are closely linked with the format requirements that have been discussed above. A consideration of photographic scales will yield much information about the required flight parameters such as altitude, percentage overlap, photographic area covered by frames and flight lines, and the spacing of flight lines to achieve desired coverage. Examples of these relationships are listed in

Table 10, where the data are based upon common 9- by 9-in. photography obtained with a camera having a 6-in. focal length. It becomes evident from the above example that, for a given altitude, a simple ratio exists that relates scale to the focal length of the camera system employed.

76. For the acquisition of existing imagery, mission planners will find that a wide range of scales is available commercially and from State or Federal agencies. In many cases, a given agency or source will obtain imagery at certain common scales. Where these scales are not compatible with the mission needs, planners will necessarily be required to consider alternative photographic methods of producing products that are compatible with mission requirements. Thus, early consideration of scale requirements of final products is essential to planning future missions.

Review of available coverage

77. Since the early 1930's, an enormous amount of remotely sensed imagery has been acquired by private, governmental, and military organizations over large parts of the world. The nature, quality, and specifications of these coverages differ considerably because of the varying purposes for which the imagery missions were flown. A general lack of communication exists concerning the availability of this imagery, due primarily to the scope of operations conducted by the various organizations acquiring the imagery. It is becoming increasingly important that existing imagery be identified in terms of type, coverage area, date of coverage, and the organization holding it. Because of the increasingly high costs involved in obtaining new imagery, users must utilize existing imagery to the greatest extent possible. Often the users unnecessarily duplicate existing imagery, primarily because they do not know that similar coverage of their areas of interest is already available.

78. Additionally, the availability of older imagery is becoming vitally important to users engaged in applications in which physical, environmental, and cultural changes, occurring over a period of time, provide significant impact to their investigations. Older imagery constitutes an important reference point for the study of these changes. In many instances, older coverages may represent the only imagery

available to users due to changes in the accessibility to certain areas of the world for political or military reasons, or both.

79. The second step in planning a photographic mission is determining what imagery is already available. After this process has been completed, the photographic mission itself may be unnecessary. Therefore, a summary has been made in this report that provides District personnel with data on existing remote-sensing imagery (Tables 11-14). The tabular material containing this information covers a significant portion of the Federal and State sources pertinent to the needs of the Mobile District. Other sources that maintain libraries of past imagery are too numerous to discuss in detail; however, the major sources are summarized to facilitate a search or inquiry as needed.*

80. Data describing the location, types, characteristics, availability, and costs of remote imagery acquired and held by various agencies[10] are contained in Tables 11-14. Although an attempt was made to use similar formats for each table, some differences do exist. These differences are due mainly to variations in agency policies and functions and are primarily restricted to product cost data. A brief explanation concerning data tabulation and comments regarding the use of the data are contained in the following paragraphs.

81. Agency or organization. An effort was made to ensure that only the part of an agency directly responsible for the acquisition, storage, or distribution of remote imagery is listed for contact purposes. In those instances in which the agency is divided into field regions or offices, all offices and respective addresses are listed.

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* It should be pointed out that the sources of available imagery described herein do not represent all possible sources of imagery. Users of information contained in this summary should keep in mind that the type, number, and location of organizations active in the field of imagery acquisition and utilization are by no means static. No attempt has been made to describe the imagery holdings of private business firms involved in engineering and photogrammetric aerial surveying. However, since these firms acquire and retain large volumes of imagery on a continuing basis, the potential user should remain cognizant of this valuable source of data.

82. Type of imagery. The principal types of remote imagery products held by the agency and available for use by individuals outside of the agency are listed. Remote imagery of a very limited extent, or of an experimental nature, was generally excluded or noted to that effect. When readily available, additional data concerning the technical characteristics of the imagery type (e.g., wavelength, etc.) were given. Unless noted otherwise, the quality of imagery types listed in the tables should be generally acceptable for varied use. However, the user should verify imagery quality in terms of project requirements before ordering specific coverages.

83. Availability and characteristics of imagery. The availability of imagery, imagery format, reproduction facilities and limitations, and types of coverage indices available are described as well as miscellaneous imagery characteristics, such as whether imagery was obtained with vertical, oblique, or panoramic camera systems, etc. Nearly all Federal and State agencies make their imagery holdings available to other Federal and State agencies, either for purchase or on a loan basis.

84. Products available. Various imagery formats are normally available from agencies producing remote imagery. The data contained in this part of Tables 11-14 describe the type and size of the imagery, the form in which the imagery exists, and the unit costs. The most common format available is the 9- by 9-in. negative and contact print. Panchromatic, color, and color IR images are normally produced in the 9- by 9-in. format.

85. Costs of products. The costs of the products available, where known, are based on published cost lists that are maintained by the larger Federal agencies. The majority of Federal and State agencies do not maintain standard cost lists or descriptions of imagery holdings for the purpose of distribution to the public. These agencies normally supply information and figure costs for reproduction of imagery on an individual request basis. Costs are generally held to the minimum necessary, with most agencies charging only for the cost of materials used. Some agencies, however, do include costs for overhead expenses in the total cost of reproduction. The user should anticipate slightly

higher costs for the reproduction of imagery by contractors holding the original negatives.

86. Federal agencies. These organizations are primarily in the major departments and independent agencies of the Executive Branch of the Federal Government, such as the Departments of Agriculture, Commerce, Interior, and Defense, as well as the Environmental Protection Agency, Tennessee Valley Authority, etc. Only those agencies having readily available imagery products for sale or loan have been included herein (Table 11). Some of the organizations contacted, while using remote imagery products of various types, obtained these products from other Federal agencies for internal use only. These particular organizations are not included in this study because the products are more readily available to the user from the agency that originally acquired the data. Several of the Federal agencies with available imagery have geographical divisions and districts (Corps of Engineers) or regions (Bureau of Reclamation) that subdivide their areas of jurisdication within the United States. Imagery available from these agencies are tabulated by appropriate division, district, or regional offices when possible.

87. EROS Data Center. One of the single major sources of aerial remote-sensing imagery for the United States is the EROS Data Center, which provides a versatile search-and-inquiry system for specific geographic areas. The WES initiated searchs for recent aerial imagery of the Mobile District that could be of assistance to the wetlands mapping described in Part V of this study. The criteria placed on the search were as follows and were felt to represent the most ideal conditions for routine monitoring photography:

Time frame:	1 January 1972 to 1 January 1978
Quality:	$\geq$ 5
Cloud cover:	$\leq$ 20 percent
Scale:	1:20,000 to 1:35,000
Type of imagery:	Black and white, color, and color IR; aerial mapping standard or NASA aircraft standard; photo index, roll film series, or single photo

88. A geographic search by EROS, free of charge to all interested parties, provides the worker with data from one of the largest imagery libraries within the Federal government. Annual updates of recent District coverage should be considered to supplement mission planning within the tasks of detection and monitoring.

89. Corps of Engineers. Those organizational units within the Corps that appeared to possess aerial imagery applicable to Mobile District needs are summarized in Table 12. The availability of imagery from these sources is usually quite good and loans or reproductions of existing materials can usually be obtained by directing inquiries to the offices listed.

90. State agencies. It was found that the State highway departments generally held most of the remote imagery acquired within the states. Other major State organizations active in the acquisition and storage of remote imagery are planning offices, environmental and natural resource departments, geological surveys, tax commissions, and water resources departments. Many of the State agencies use imagery products that are obtained from Federal agencies or, in some instances, from State agencies, such as highway departments. State sources of imagery have generally been limited to those organizations that have acquired coverages through in-house capabilities or by contracted services. Sources of imagery pertinent to use by the Mobile District are listed in Table 12.

91. Procedures for obtaining imagery. The data contained in the tables do not generally provide sufficient information for the direct ordering of imagery. However, information has been provided in the tables to enable potential users to make the necessary initial contact with an agency for obtaining desired imagery. The principal Federal agencies engaged in large-scale imagery acquisition and distribution programs generally provide detailed ordering instructions for potential users to follow. These instructions will be found in the appropriate sections of the tables. Those agencies that acquire remote imagery primarily for internal use do not normally distribute information concerning procedures for potential users outside of the agency to

utilize for ordering purposes. For this reason, no detailed information pertaining to procedures for obtaining imagery from many of the agencies is listed in the tables. However, the titles of individuals or offices within the agency that potential users should contact initially have been identified and included in the tables. The use of specific names of individuals has been avoided wherever possible because of possible changes in personnel in the future.

92. Most agencies contacted have their imagery indexed, either by flight lines delineated on maps, photo indices (showing individual overlapping photographs arranged along flight lines), catalog indices, or card indices. The user must obtain copies of these indices to select specific coverage.

93. Two or three contacts will probably be necessary to obtain any imagery from the agencies. Preliminary contacts with the agencies can be minimized if the user can provide as much information as possible to the agency he contacts. Most of the agencies contacted during this study stressed the value of locating the area of interest on some type of map. If maps are not available, the user should make a rough sketch map of the location for which he desires coverage. If the user has obtained index material from the agency, the date of photography, roll number, print number, and project symbol should be included with his order. The user should indicate the size of the print desired (e.g., 9 by 9 in., contact print, or some enlargement) and the material on which the image is to be printed (e.g., single- or double-weight paper or transparency). When appropriate, the user should describe the purpose for which the imagery is to be used. The agency may detect any obvious discrepancies between the ordered product and the projected use. Stereo coverage or pictorial coverage should be indicated.

Review of sources from which
new imagery can be obtained

94. At that point in mission planning when the objective has been clearly defined and a search has been made to determine whether existing photography can be obtained for part or all of the coverage needed, planning personnel must focus their attention upon the possible need to

contact Federal, State, or private sources that can obtain new imagery. Because of the expanding role of remote sensing in such areas as environmental management, energy studies, ecological studies, engineering and mapping surveys, military intelligence, etc., the inventory and variety of aircraft and sensors employed in acquiring remotely sensed data have steadily increased during the past decade. This array of aircraft and sensors represents a potentially valuable source of hardware for government and military personnel engaged in environmental management that requires various types of remotely sensed data.

95. Private companies and educational institutions. Table 14 lists the firms in the Mobile District vicinity active in the field of remote sensing as compiled from various published sources. These firms collectively operate a large number of aircraft and sensors that encompass a tremendous variety of aircraft and sensor types. Many of these firms offer complete remote-sensing services in earth science and environmental applications, using high-performance aircraft with onboard multisensor systems.

96. Table 15 lists selected universities in the Mobile District area that maintain remote sensing programs or laboratories. The principal university department responsible for remote sensing research and the major application(s) for which research is conducted are also identified.

97. Government agencies and military organizations. Government and military aircraft-sensor packages include a large variety of aircraft and photographic, scanning, and imaging systems, complemented by various levels of supporting instrumentation and techniques. The aircraft range from small single-engine platforms carrying a single camera to large multiengine aircraft with complex multisensor systems. These aircraft-sensor configurations offer capabilities in the following major fields of interest:[11]

a. Aerial photography

(1) Panchromatic

(2) Color

(3) Color IR

(4) Black-and-white IR

(5) Multispectral

b. Thermal IR

c. Multispectral additive color

d. Multiband imagery

e. Side-looking airborne radar (SLAR)

f. Gravimetric and magnetic

g. Environmental monitoring instrumentation

h. Gamma ray

i. Meteorological monitoring instrumentation

98. Sufficient information is provided herein regarding the sources, types, and availability of government and military remote-sensing aircraft to enable potential users of remote sensing imagery to take advantage of, as appropriate, the systems and capabilities that are currently available. However, the availability of the many excellent commercial firms engaged in the acquisition of remote imagery should not be neglected by users in favor of governmental and military organizations. On the contrary, commercial firms still represent what is probably the largest source of conventional and unconventional remotely sensed data available to users. However, the user who is presented with a need for new imagery to satisfy certain project requirements and has limited funds available for mission support may be able to arrange with a government agency for a low-cost mission.

99. Federal and military remote-sensing aircraft. Data describing the sources, availability, and operational characteristics of remote-sensing aircraft operated by U. S. Government agencies and military departments in the Mobile District area are contained in Tables 16 and 17. Data elements of these tables and comments relative to use of these data are contained below.

100. Agency/department and organization. The major department/agency and its subordinate organization(s) in which remote-sensing aircraft are located are identified in this section. The subordinate organizations listed are limited to those directly responsible for the scheduling, application, and operation of the aircraft.

101. Aircraft. Data in this section identify the type of aircraft by manufacturer, model number, and name (when available); pertinent operating characteristics, e.g., service ceiling, speed, range, and endurance; and power plant configuration. When possible, flight characteristics of the aircraft were obtained from crew personnel familiar with the aircraft. In those instances in which crew-supplied information was unavailable, flight characteristics of the subject aircraft were obtained from published sources. The operating characteristics may differ somewhat between aircraft of the same manufacturer and model. This difference is due primarily to factors such as organization of flight standards, pilot preferences, sensor configurations, and age of aircraft. The data pertaining to the available aircraft are necessarily brief. However, Tables 16 and 17 should provide potential users with sufficient comparative data to determine the relative capabilities of the various aircraft types. Additional data can be obtained from aircraft manufacturers.

102. Availability is perhaps the chief factor involved in aircraft selection, but the following additional factors should also be considered:

- a. Intended application.
- b. Sensor configurations
- c. Operating costs.
- d. Aircraft performance characteristics (capabilities and limitations).
- e. Physical and environmental characteristics of the area in which the aircraft must fly.

103. Sensors. Available cameras, infrared systems, microwave/radar systems, meteorological/environmental sensors, and miscellaneous support sensors have been identified for remote-sensing aircraft listed in the tables. Most of the sensors have been identified by manufacturer and model number. Pertinent sensor characteristics, such as focal length, film size, spectrum range, etc., are also briefly described. The availability of multiple sensors within a particular organization does not necessarily imply that all of these sensors can be collectively

installed in an aircraft as a multisensor system. Many of the Federal and military organizations design their aircraft so that various sensors can be interchanged freely. This provides greater mission flexibility for those organizations having only one aircraft, or aircraft whose operational and design characteristics preclude the installation of multisensor systems. However, some Federal government and military aircraft are specifically designed or have been modified to carry multisensor arrays. This is particularly true of most military reconnaissance aircraft, such as the RF-4C and OV-1D, which carry several cameras, infrared detection systems, and side-looking radar. Before any final decisions are reached regarding the type of sensor(s) and aircraft to be used for a specific application, the user should carefully consider the desired spectrum, required coverage, and resolution required.

104. Availability. Information was obtained from each of the Federal and military organizations contacted to determine the general availability of its respective aircraft-sensor systems. Although nearly all of the organizations indicated that their policy was to make aircraft available to other Federal and military elements when possible, there are several conditions reflecting agency policy that can affect aircraft availability. Some of the most common constraints imposed on the availability of aircraft by various agencies are as follows:

a. Availability of aircraft depends on the work load of the controlling agency, i.e., aircraft can perform mission support for other agencies only during off or slack periods in the controlling agency's work schedule.

b. Mission support is restricted to research-oriented projects only; e.g., conventional aerial mapping surveys may not be supported.

c. Mission support is restricted to those projects or applications of a nature similar to that in which the aircraft are regularly used.

d. Mission support is restricted to certain geographical areas due to factors such as administrative policies, logistics, and operational characteristics of aircraft and/or sensors.

105. The constraints listed above are rarely imposed collectively by an individual organization. Some of the Federal agencies do limit

mission support to projects of a research nature or to applications for which the onboard sensors were specifically designed. A number of the military units contacted indicated that the availability of their aircraft often depends on the location of the mission area. Some units prefer not to fly missions that are outside the range of their aircraft. This is particularly true of Reserve and National Guard reconnaissance units. Training missions, conducted at long distances from the home base, often present logistical support and personnel availability problems as a result of staging missions from inadequate or new bases. The active reconnaissance units of the Army, Navy, and Air Force are generally more responsive to long-range missions or missions of extended duration. However, some of these units are assigned certain geographical areas of responsibility that may limit the areas in which they actually operate. For example, the Air Force's 363d Tactical Reconnaissance Wing (TRW) is generally responsible for the area of the United States east of the Mississippi River. Missions flown west of the Mississippi River are normally accomplished by the 67th TRW.

106. Potential users are reminded that the availability status of remote-sensing aircraft identified herein is by no means static. Virtually all of the Federal and military organizations contacted during this study emphasized the need for mission requests to be placed well in advance of the requirements. Some organizations indicated that they require as much as a 1-yr lead time for the scheduling of mission support.

107. Costs. The costs of remote-sensing missions depend in a very complicated fashion on numerous factors (Table 18). Therefore, it was frequently difficult to obtain general cost information. However, when the information was available, hourly cost data for the operation of various types of aircraft-sensor sytems were obtained from the agencies contacted during this study. The cost data provided in Tables 16 and 17 should be used for general guidance only, since hourly rates will probably continue to increase in the future. Some of the agencies contacted were reluctant to furnish cost data until the precise nature of the mission and aircraft-sensor requirements were known.

108. Generally, costs may be anticipated to increase as the size and performance capabilities of aircraft increase. However, high-altitude aircraft, e.g., jet- and turbine-powered aircraft, consume considerably less flying time due to their higher speed and altitude capabilities. This factor may have a significant influence on overall costs for imagery missions encompassing large project areas. If the user can achieve project objectives with small-scale imagery, such as 1:120,000, mission costs[12,13] may be substantially reduced (Table 19) even though hourly operating costs of high-performance aircraft are higher. Most agencies compute principal costs (crew per diem, standby time, film processing, etc.) for use of aircraft-sensor systems on a daily or fixed basis. Costs for crew salaries and fuel are normally included in the hourly aircraft operating cost.

109. A small number of Federal agencies will provide mission support to other governmental agencies at no cost. However, the user must provide very strong justification (normally of a research nature) to the agency in order to obtain support of this type. Most of the military organizations will provide mission support to Federal agencies for the costs of film, processing, and in some instances, crew expenses if the mission can be accomplished as a part of regular training programs.

110. Mission requests. The information relative to mission request procedures provided in Tables 16 and 17 should enable the potential user to make initial contact with organizations having aircraft-sensor systems of the type he requires. Mission request data include name or designation of organization, address, location, and point of contact (when appropriate).

111. In most instances, the organization directly responsible for the operation of aircraft-sensor systems can be directly contacted by the user. This is primarily applicable to the Federal civilian agencies. However, those organizations in the Department of Defense (DoD) (e.g., Army, Navy, Air Force, and in some instances, the National Guard units) have established certain procedures and regulations for the submission of mission support requests. Mission requests from Federal

civilain agencies to DoD elements normally should be forwarded to major commands rather than to the subordinate units directly responsible for conducting the missions.

112. Present DoD policy is that imagery mission support to any private individual, group, institution, or commercial enterprise is generally prohibited since it is regarded as being competitive with similar civilian imagery acquisition services (Air Force Regulation 95-8, 31 January 1975). However, the DoD may provide such support to other agencies as follows:

<u>a</u>. To other Federal agencies, after appropriate validation, depending on the nature of the request and on whether DoD resources are available to satisfy the request.

<u>b</u>. To non-Federal agencies (State, county, and local governments); support is limited to national or civil emergency requirements. Requests from non-Federal agencies for imagery mission support that can be provided by commercial firms or agencies other than the DoD will be disapproved.

113. <u>State remote-sensing aircraft</u>. The following information is contained in Table 20: (a) State, name, address, and location of the organization to which the aircraft are assigned; (b) aircraft type and nomenclature; (c) sensor type and nomenclature; and (d) identification of imagery acquisition methods used by those states having no remote-sensing aircraft. It is assumed that State agency-operated aircraft and sensors would be available to support mission requests from Federal agencies, although information to validate this assumption is lacking. However, State aircraft do provide a great deal of support to State agencies within and, in some cases, outside of the home state.

<u>Mission specifications</u>

114. <u>Appropriate altitude</u>. The altitude at which aerial photography is to be acquired has been partially discussed in the earlier sections concerning scale requirements (paragraph 56). In addition to scale factors, the altitude of a given set of imagery will place limits upon the coverage obtainable from final products. The primary limiting factors that affect imagery at different altitudes are the focal length of the camera system being utilized for the mission and the resolution capability of the aerial film employed.

115. Figure 26 shows the relationship between focal length, scale, and ground coverage. Figures 27-30 illustrate the change in resolvable ground distance for five aerial films and three focal lengths as altitude is increased.[7] It is evident that as focal length increases, the ground area decreases for a given altitude. Figure 31 illustrates a simple problem concerning the computation of a desired flying height of an aircraft given the factors of camera focal length and desired scale. Taking this relationship into account during the planning stage of any mission will avoid the possible acquisition of expensive imagery incapable of yielding needed information.

116. Optimum time for coverage. The selection of the optimum time for aerial coverage to be acquired must, in most instances, be determined from the role(s) played by one or both of the following factors. First, the appearance of vegetation and landforms or hydrologic features will vary considerably with the season of the year when the imagery is acquired. The Corps of Engineers frequently obtains much of its imagery during low-water periods in the fall and also during high-water periods in the spring. Such timing of imagery acquisition will provide much information concerning areas prone to flooding and areas where wetland plant communities may be found or potentially occur.

117. In certain instances, a mission may be directed toward obtaining information that can be correlated with the foliage conditions of certain plant communities. In these cases, particularly in upland and swampy forested locations, a "leaf-on" or "leaf-off" season criterion may be used in planning. Whenever a situation occurs where choices similar to the above are necessary, the user should carefully consider the type of coverage best suited to the intended application.

118. To provide some guidelines for the Mobile District to consider in planning its acquisition of imagery near the Gulf Coast, the WES discussed this problem in terms of wetlands discrimination with several individuals concerned with detecting plant communities with aerial photography:

Dr. Glen Montz, U. S. Army CE District, New Orleans.

Mr. Porter Reed, U. S. Department of the Interior, National Wetlands Inventory (USDI-NWI), St. Petersburg, Florida.

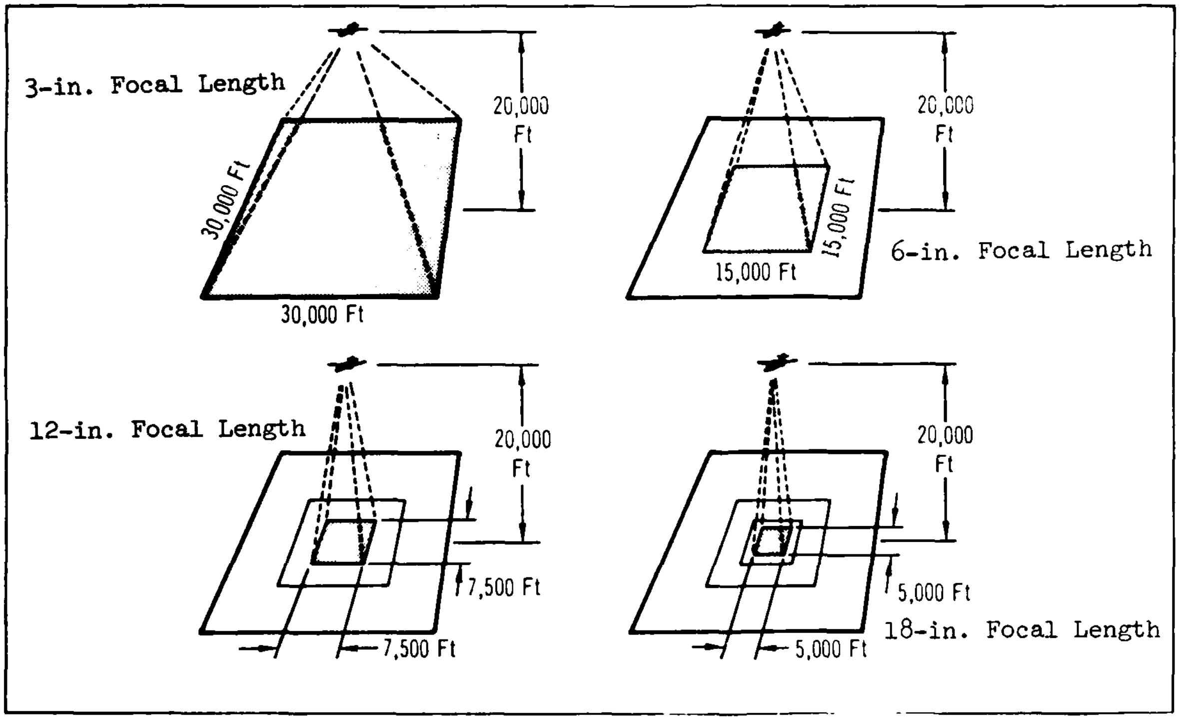


Figure 26. Effect of focal length on scale and ground coverage

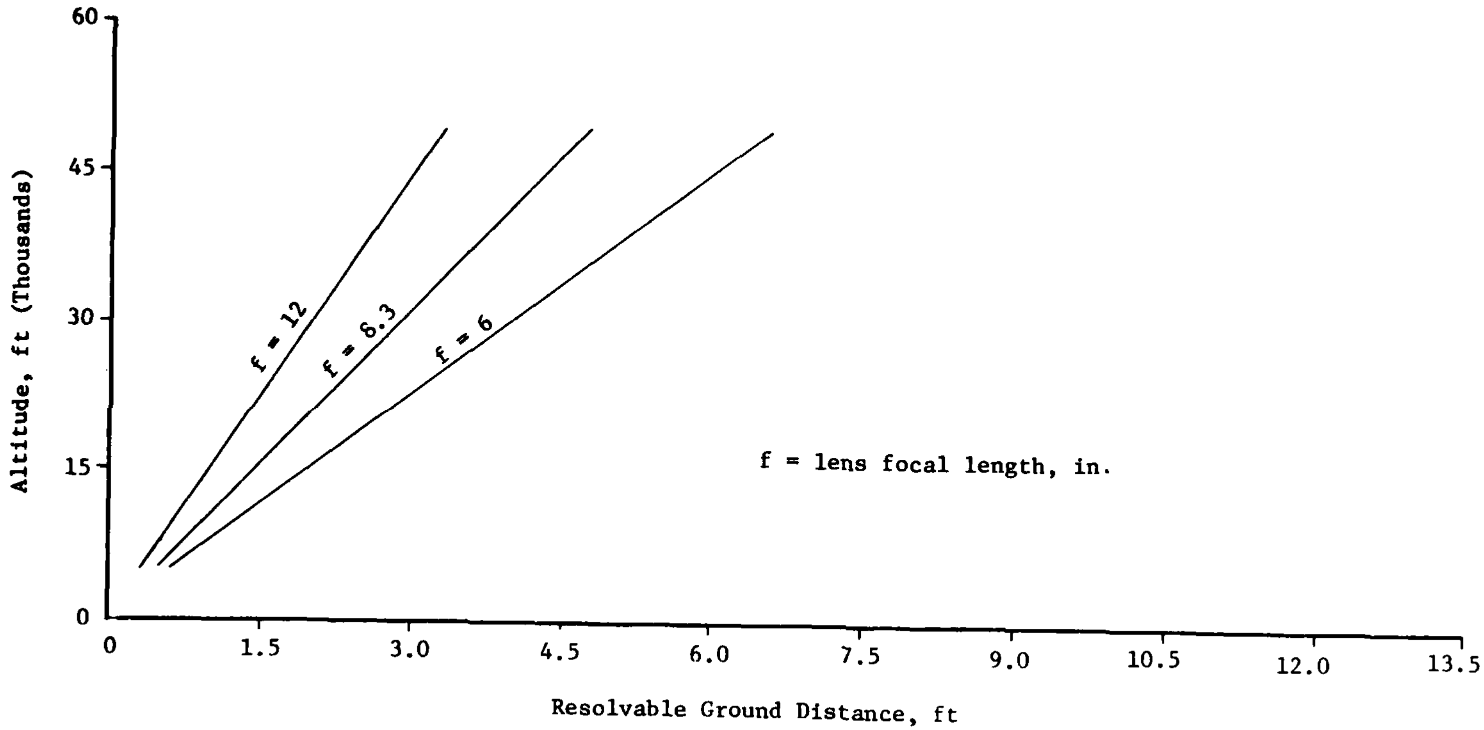


Figure 27. Resolvable ground distance as a function of altitude for Kodak Plus-X Aerographic Film No. 2402

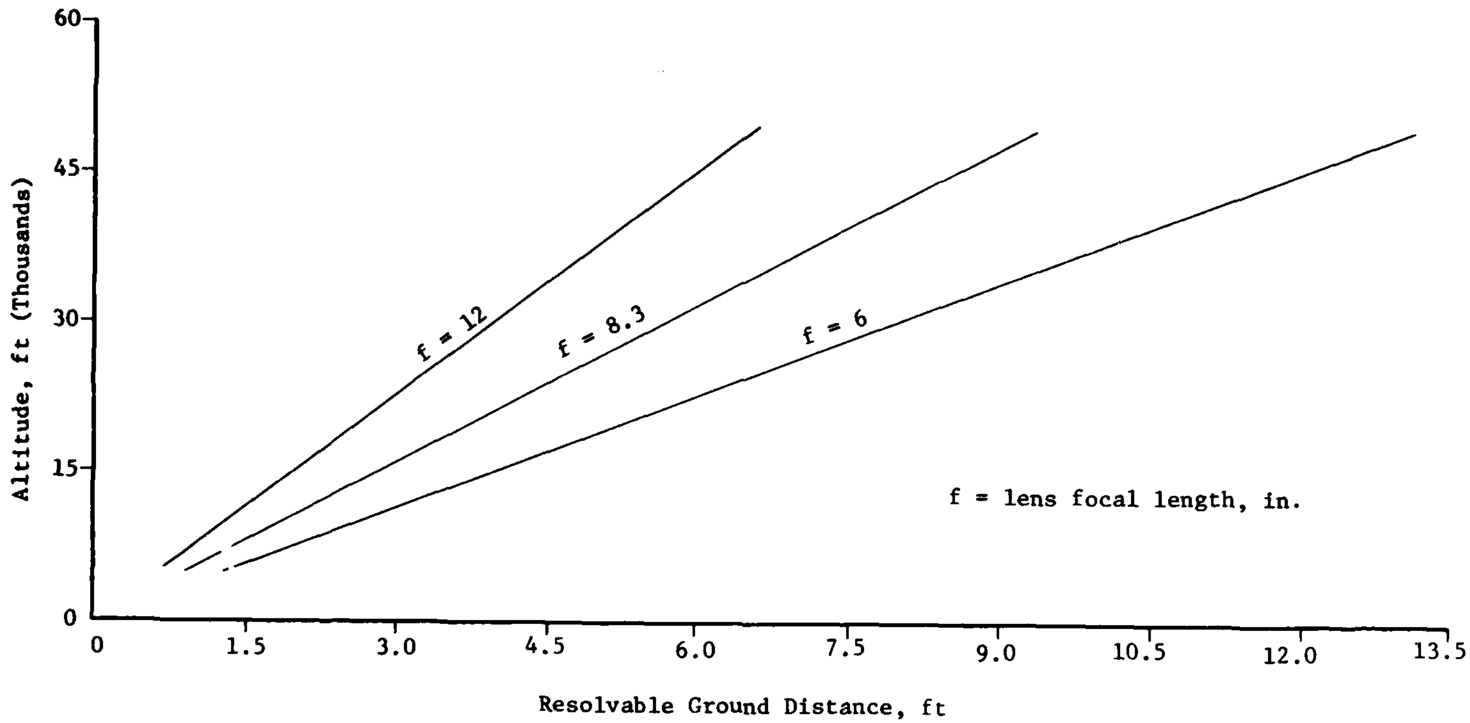


Figure 28. Resolvable ground distance as a function of altitude for Kodak TRI-X Aerographic Film No. 2403

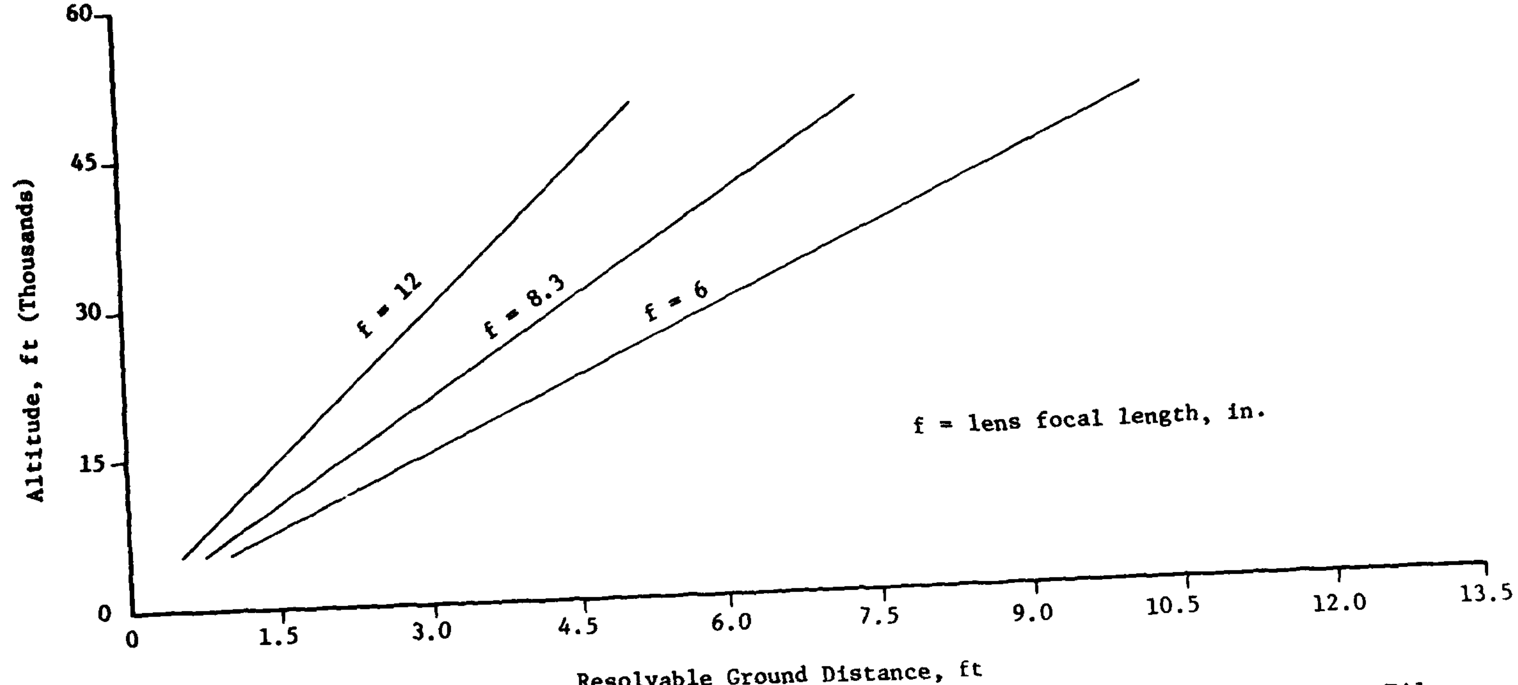


Figure 29. Resolvable ground distance as a function of altitude for Kodak IR Aerographic Film No. 2424 and Kodak Aerochrome IR Film No. 2443

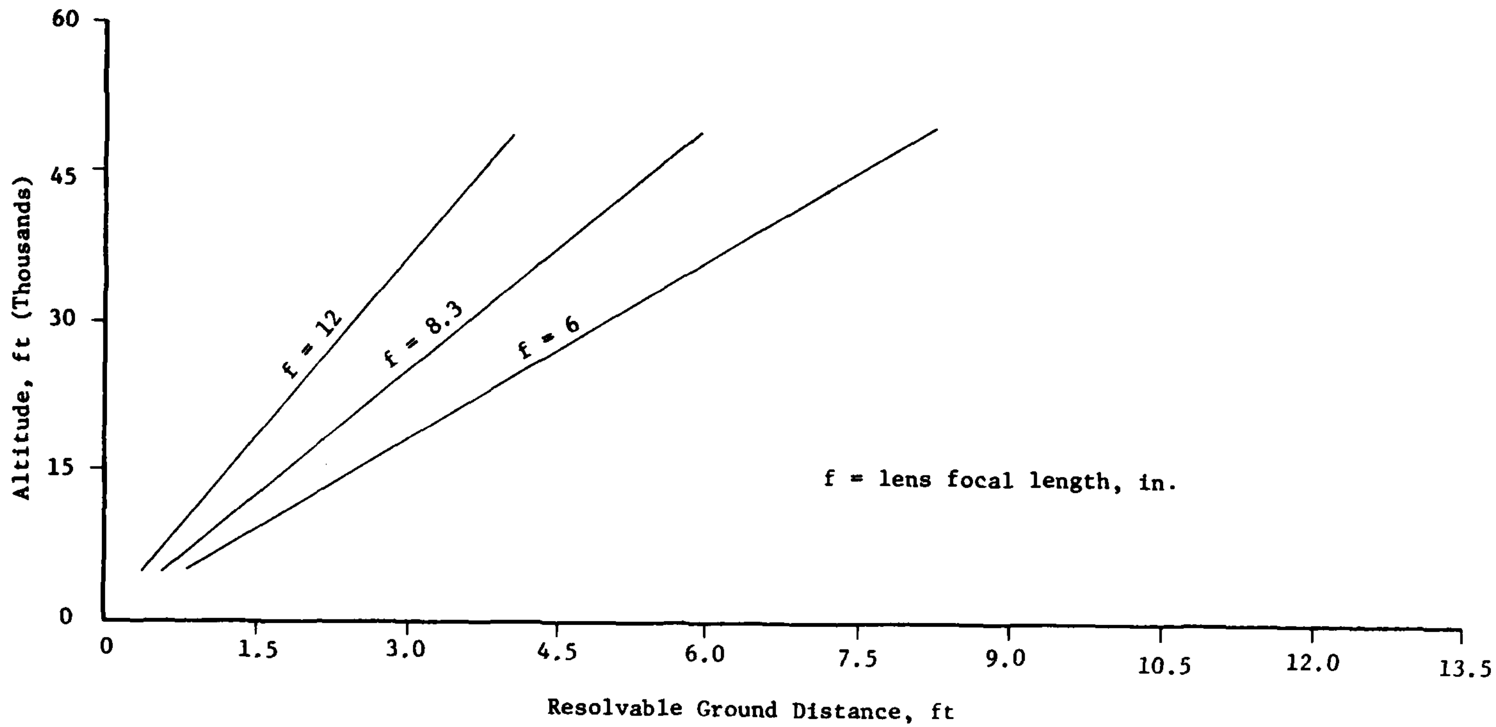


Figure 30. Resolvable ground distance as a function of altitude for Kodak Ektachrome MS Aerographic Film No. 2448

ALTITUDE = f/Photo Scale

f = Focal Length of Camera in ft

EXAMPLE:

Focal Length of Camera = 6 in. or 0.5 ft

SCALE = 1:24,000 or $\frac{1}{24,000}$

Altitude (Flying Height) = 0.5/(1/24,000)

Altitude = 12,000 ft

Figure 31. Computation of flying height of aircraft

Mr. Pat O'Neil, USDI, U. S. Geological Survey (USGS), NSTL, Bay St. Louis, Mississippi.

In general, it was felt that the time frames indicated on Figure 32 would provide acceptable information about plant and aquatic communities. Table 21 contains additional information concerning optimum time for detecting specific features.[14]

119. The second factor to consider with respect to the time for coverage concerns the influence of solar and atmospheric conditions upon the quality and information content of aerial imagery. Within this factor, the following phenomena will play major roles in the production of useful photography:

a. Solar altitude

b. Percent cloud cover (and probable occurrence of cloud-free days)

c. Presence of smoke, haze, dust, or other particulate material

Normally, high-quality imagery is not obtained as readily for level or rolling landforms when the solar elevation angle is less than 30 deg. Lesser angles will often produce objectionable shadow images by vegetation, structures, or land features and will thus obscure or distort needed information. Not infrequently, surface features with extreme slope variations will require even more restrictive solar angles and consequently will shorten the useful daylight window on remote-sensing missions. Figure 33 illustrates the relationship between the length of useful daylight time when the sun is $\geq$ 30 deg in elevation, the latitude of a location to be photographed, and the date of the year.[15]

120. Local conditions will vary considerably for environmental factors that will affect imagery. As a result, climatological tables that are published by the National Weather Bureau for areas under consideration will frequently give good supporting data concerning the probability of cloud-free days expected to occur during a period selected for missions to be flown. Also, many local sources of information can provide data about seasonal events peculiar to a specific locale that are not reflected in the sources compiled by State and Federal agencies (e.g., seasonal burning or industrial activity).

121. Optimum film-filter combination. The informational content of a remote sensor image is entirely a function of the spatial variation of the optical density values (gray tones or colors) comprising the image and of the investigator's ability to place these variations within a meaningful context and translate them into desired information. It would be ideal if the variations in image optical density were always directly and exclusively related to changes in feature materials (e.g., sand, wood, or metal) or conditions (e.g., wet sand or wood). Unfortunately, this is hardly ever the case. At best, variations in image optical density values are directly related to changes in the reflectance of materials that may or may not be related directly to the material changes of interest to the investigator. Additional uncertainties are added in that the optical density values on an image are the resultant of interactions of light with the atmosphere and the sensor system itself as well as the aforementioned interaction with feature materials. The atmospheric and sensor system influences have been shown to be very significant with respect to the optical density variations resulting from changes in material type or condition.[16] In addition to the above interactions, the reflectance geometry (i.e., the geometric relations among incident solar light, feature, and sensor system) can have considerable influence on the optical density values of an image.

122. Because of the many interactions and complex geometry involved, it is entirely conceivable that variations in optical density values can occur without associated variations in the type or condition of feature materials. Conversely, changes may occur in the feature without producing a detectable change in optical density. The fact that these things can and do occur, complicates the detection of change in both spatial and temporal frameworks. To satisfy the need to have available a means for considering the complex phenomena that influence imagery informational content so as to minimize the effects of the phenomena not related to changes in feature materials, the WES developed a procedure for planning remote-sensing missions to optimize the resulting imagery with respect to the desired information.[9]

LEGEND

a. Limited success with differentiation of some aquatic communities; good for standing water.
b. Good for upland wetlands boundaries.
c. Good for new marsh growth.
d. Poor for many herbaceous wetland communities.
e. Good for marsh boundaries.
f. Good for "leaves-off" conditions of wetland hardwood communities.
g. Good for early coniferous growth and differentiation of conifers from "leaves-off" condition of broad-leaf wetland communities.
h. Poor for broad-leaf wetland communities.
i. Good for Taxodium communities.
j. Good for new leaves of broad-leaf forms and high standing water.
k. Poor for marsh communities generally.
l. Good for annual marsh die-back.
m. Good for maximum annual foliar development of many wetland species.
n. Good for many herbaceous wetland communities.
o. Good for Tupelo communities.
p. Good for fully mature hardwoods.

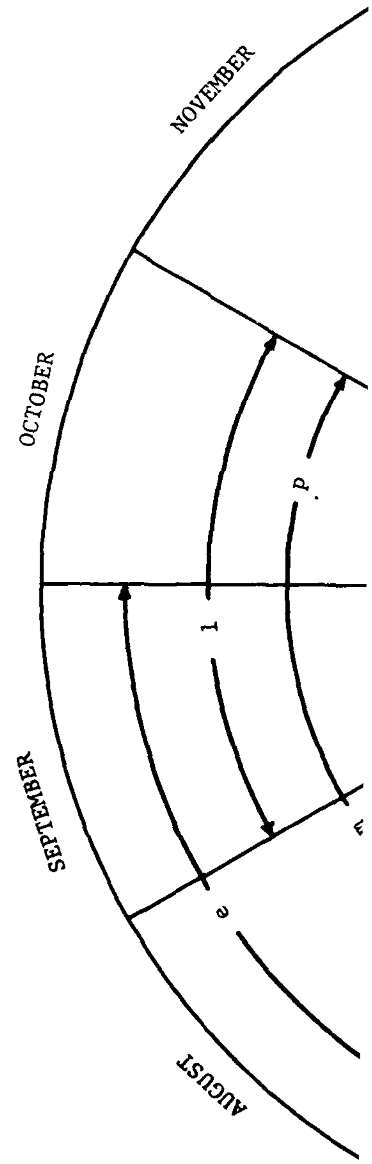
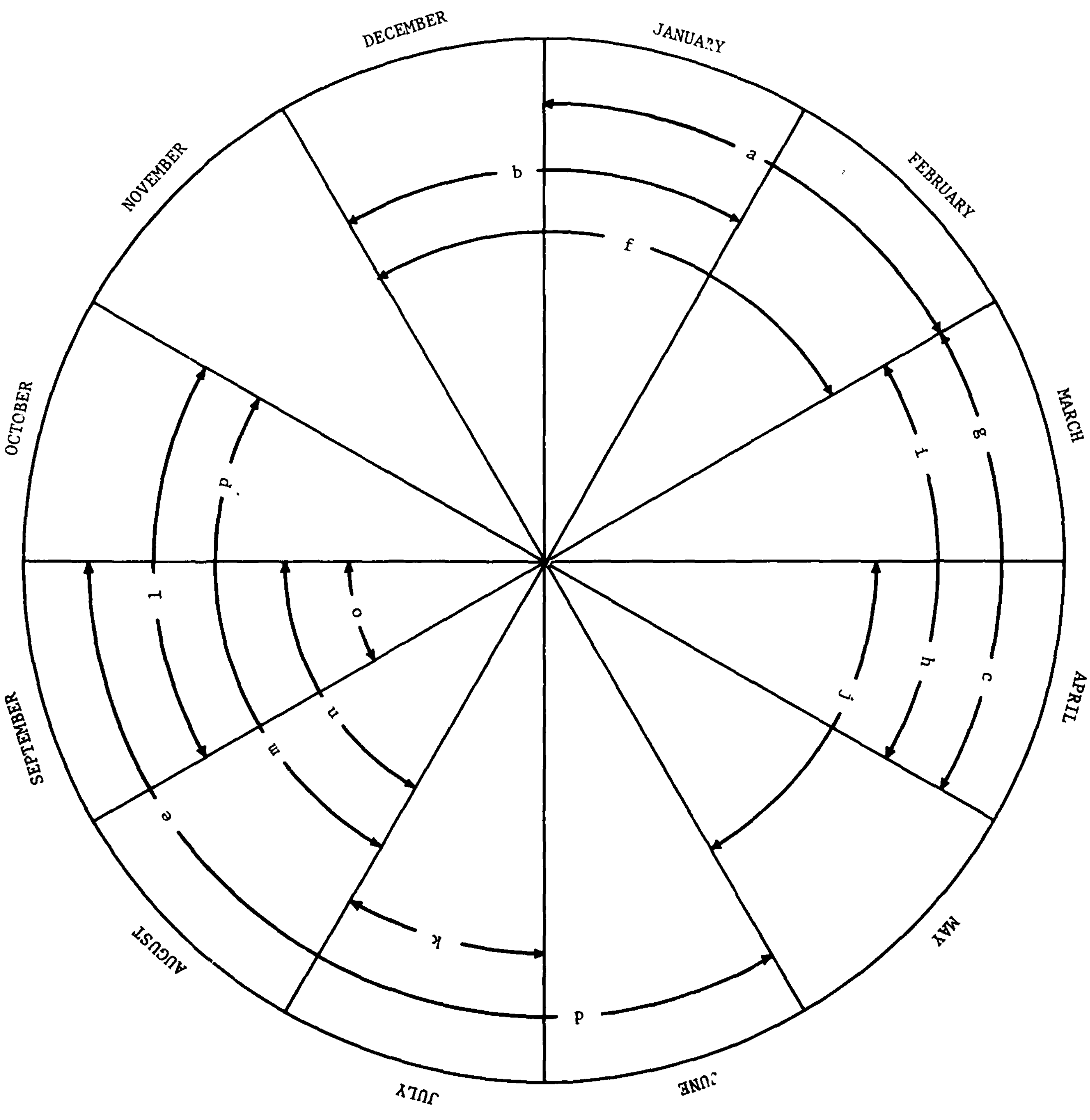


Figure 32. Suggested time frames for imag
near the Gulf Coast

2



Suggested time frames for imagery acquisition near the Gulf Coast

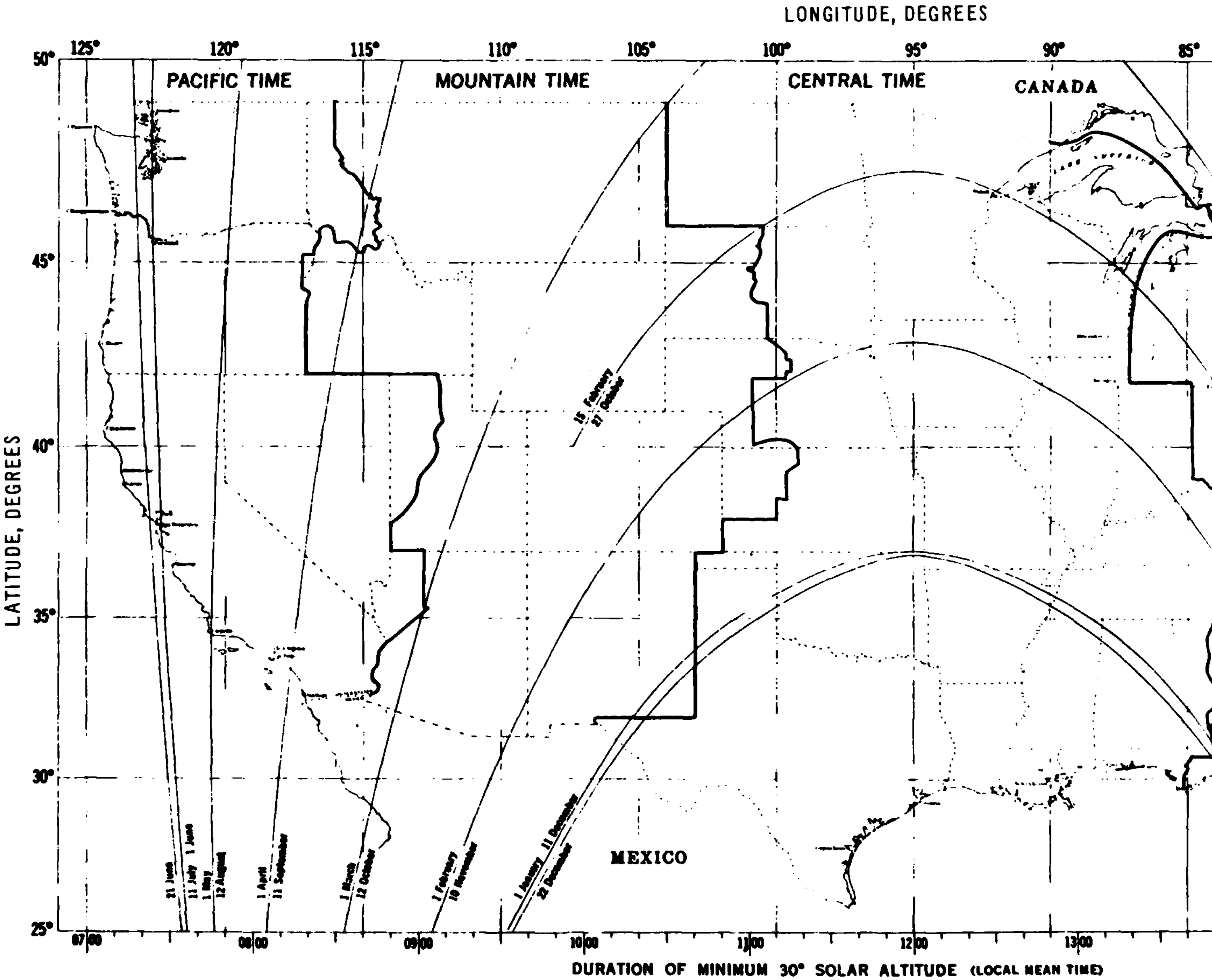
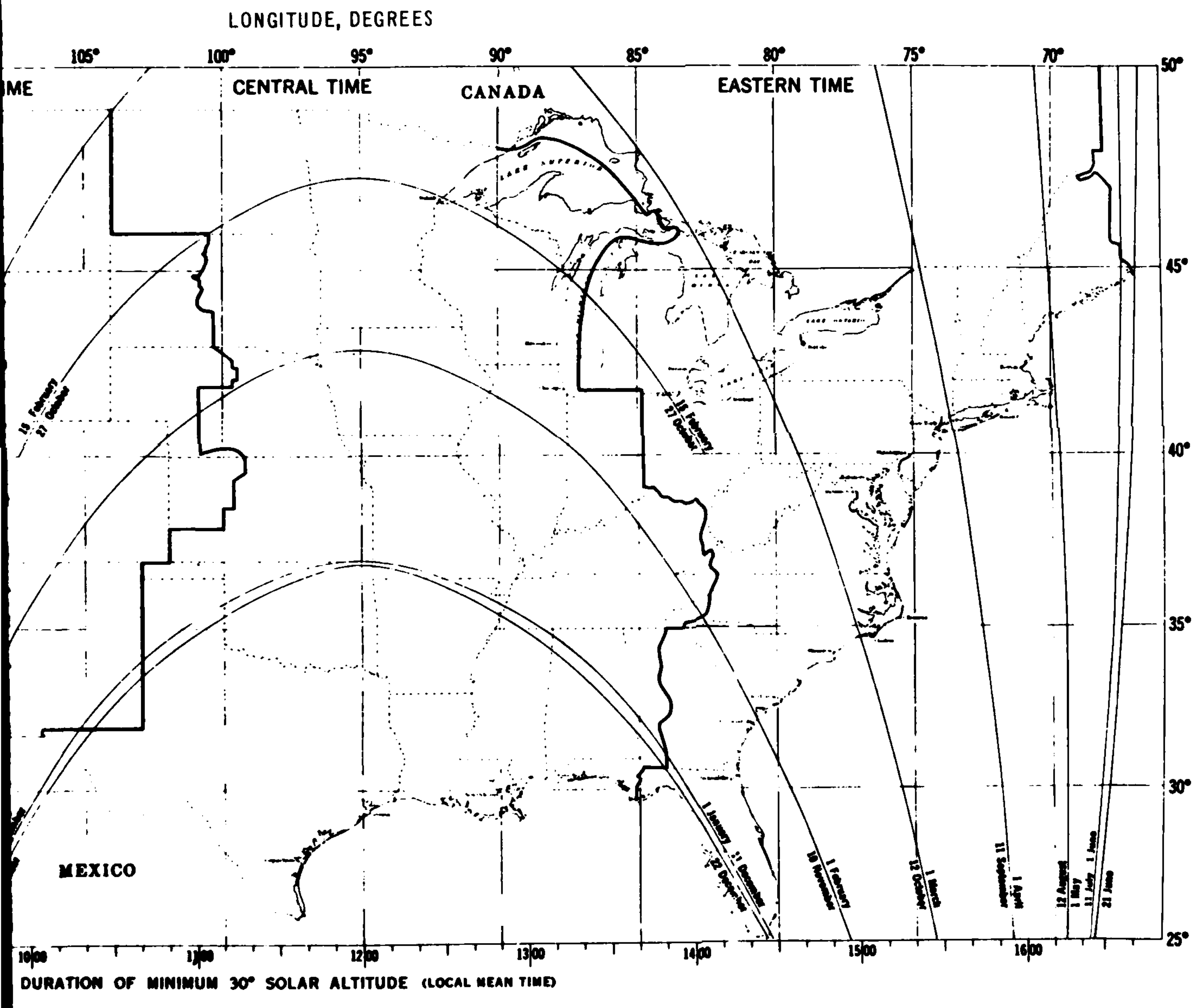


Figure 33. Relationship between solar angle, geographic latitude, and date



ip between solar angle, geographic latitude, and date for collecting imagery

1

2

123. A critical part of the procedure developed is a computerized simulation model for predicting image optical density contrasts in photographic remote sensing systems. The model, called the Photographic Systems Simulation Model (PSSM), provides a rigorous, quantitative means of examining the effects of the major variables that influence the informational content of aerial photographs. Specifically, the model can be used to predict the contrast between the images of specific features and their backgrounds, taken at various altitudes, in different atmospheric haze conditions, at different solar zenith angles, during different seasons, and with different films and filters. This makes possible the objective selection of a film-filter combination that will enhance the success of a data-acquisition mission.

124. For a specific problem (requiring a single type of data), appropriate reflectance data for both the feature and background can be input to the model and the contrast predicted for a number of film-filter combinations. These predicted values can be used to determine if the feature will be detectable directly on the imagery.

125. For a multipurpose data-acquisition program, the model can be applied to each individual feature-background composition required and the results combined to determine, overall, those features directly observable on remote imagery. For those features not directly visible on the imagery, additional analyses must be made. First, the investigator must relate the changes in these data types to physical changes in other features. This can be accomplished only by one knowledgeable in the interrelations of the surface and near-surface terrain materials. Once these relations have been defined, the model can be applied to determine if variations in the indicator feature(s) can be directly observed on remote imagery. See the sections on dikes and bulkheads in Appendix E for an example of these inferential techniques.

126. The application of the PSSM to mission planning entails the selection of the best film-filter combination for the job and the specification of acceptable mission profile parameters, such as sensor altitude, acceptable atmospheric conditions, acceptable solar zenith (time of day for a particular season at a particular location), and optimum sensor adjustments or calibration for the problem at hand.

127. The use of the model for specifying the best or most acceptable film-filter combinations for a specific purpose from a number of selected combinations is simply a matter of executing the model with the appropriate reflectance data. Application of the model for a multipurpose data-acquisition program would entail repeated use of the model and an analysis of the results to determine a single or minimum number of film-filter combinations that would be adequate for acquiring the necessary data. However, the specified best film-filter combination may and probably will vary for each required data type. In this case, the film-filter combinations deemed adequate for each data type can be compared, and a selection of the optimum combination can be made for the data-acquisition mission based on those film-filter combinations shown to be adequate for the largest number of the individual data types. Another alternative consists of flying several missions using different sensors, or if possible, one mission with multispectral capability.

128. Specification of acceptable mission profile parameters requires examination of the effects of variations of these parameters on the informational content of the remote imagery. This means that the effects of variations in sensor altitude, atmospheric haze conditions, solar zenith angle, and sensor adjustments must be examined in an orderly fashion to determine those conditions most conducive to a successful data-acquisition mission. Since the PSSM allows for the systematic control of these variables, it can be used to examine the effects of their variation on the contrast between the images of specific features as obtained with a specified sensor or sensor package.

129. Specifically, the model can be used to predict the contrast between the images of specific features or feature conditions at various altitudes, for different atmospheric haze conditions, for different solar zenith angles, and for various sensor adjustments (e.g., F-stop). The predicted contrast values are then used to examine the effect of each mission parameter on the contrast. For example, if an increase in altitude decreases the contrast significantly, or below an acceptable level, the altitude at which the mission is flown must be tailored to prevent a significant loss in contrast. Predictions at a number of

altitudes would allow specification of the maximum acceptable altitude on a spectral basis. On the other hand, if an increase in altitude does not affect the image contrast, the mission flight altitude can be selected on the basis of scale factors alone, using the spatial component of the model (Figures 27-30).

130. In the analysis of the predicted contrast values, it is necessary to examine combined effects of parameters in addition to individual parameter effects. For example, the effect of variations in atmospheric haze should be investigated for various sensor altitudes, because a change in haze conditions may not cause a significant change in contrast on images obtained at low altitudes, but may indeed create an undesirably large contrast change (decrease) for images obtained at relatively high altitudes. Similar analogies can be drawn for the other mission parameters. The increase in solar zenith angle, for example, will effectively magnify atmospheric attenuation. Similarly, variations in altitude, atmospheric haze, and solar zenith angle affect the optimum values for camera adjustments such as F-stop and exposure time.

131. To illustrate the application of the PSSM and at the same time provide the Mobile District with a useful tool for planning future photographic missions, the film-filter matrices in Appendix C were generated. These matrices are arrays of numbers that indicate the suitability of a particular film and filter combination to detect a given feature against a given background. The numbers are the optical density contrast values calculated by the PSSM.

132. Execution of the simulation model requires personnel knowledgeable in the operation of computer facilities and the basic character of the model and its inputs. Clearly, such personnel and the appropriate computer facilities are not always available. For this reason a graphical form of the model (i.e., a nomogram) has been developed[17] that provides all potential users of photographic systems with a means for predicting image optical density contrasts for quantitatively planning remote-sensing missions.

Quality control

133. Quality control provides the critical step for determining the final success or failure of a mission and will eventually provide the contracting agency with the basis for accepting or rejecting the final imagery products. It is for these reasons that careful advance consideration should be given to establishing an examination schedule and procedure that will be followed throughout the mission. In the following paragraphs, the sequence of events discussed represents a critical examination procedure and all missions may not require the degree of detail that is presented.

134. From the onset of any mission, periodic inspection of imagery products should be performed prior to the completion of the mission. Such inspections should be oriented toward evaluating the acquired material with respect to the original written specifications. By doing this, the mission can be evaluated while it is in progress, and necessary alterations to original plans can be made. Many times this evaluation can prevent the necessity of reflying parts of missions or the total loss of the opportunity for acquiring additional imagery due to inavailability of aircraft, changing weather conditions, etc.

135. The inspection process is frequently carried out in a series of one or more phases[18] that are designed to follow the logical sequence involved in obtaining final products. In some cases, not all of the following phases are performed due to the design of the particular mission; however, a rigorous procedure of examination would be

a. Inspection for defects (Table 22) in films that occurred before or during processing or during acquisition, including the consideration of the following:

(1) Snow or cloud cover

(2) Shadows

(3) Exposure characteristics

(4) Processing procedures

(5) Fog levels of images

(6) Stains

(7) Spotting

(8) Dry marks

(9) Scratches

(10) Streaks

(11) Density levels

(12) Calibration of distances

b. Examination of prints for other defects:

(1) Excessive crab, drift, and tip or tilt of aircraft (Figure 34)

(2) Conformity of flight lines and imagery format with stated requirements

(3) Side lap and forward overlaps specifications

(4) Exposure quality to meet working needs for final products

c. Stereo coverage examination (if applicable):

(1) Warpage

(2) Distortion

(3) Parallax elimination

(4) Presence of necessary carryover points throughout flight lines

d. Final analysis of the overall inspection process and formulation of a concept of the level of acceptability of final products.

136. While the inspection sequence will provide a thorough analysis in itself, several items should be considered in the planning stages that will act as ancillary aids to the evaluation process. Each of these aids should be developed as the mission proceeds to its completion and should be made available to evaluating personnel as they perform their tasks. These aids include:

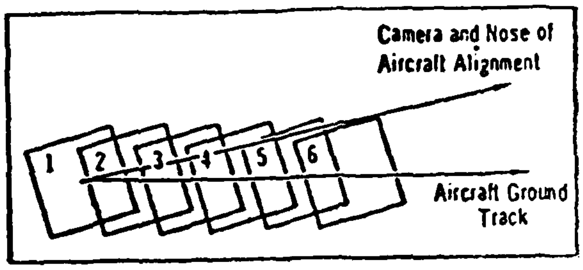
a. A series of small-scale progress maps (e.g., 1:1,000,000 scale).

b. A complete set of periodic and scheduled progress and inspection reports.

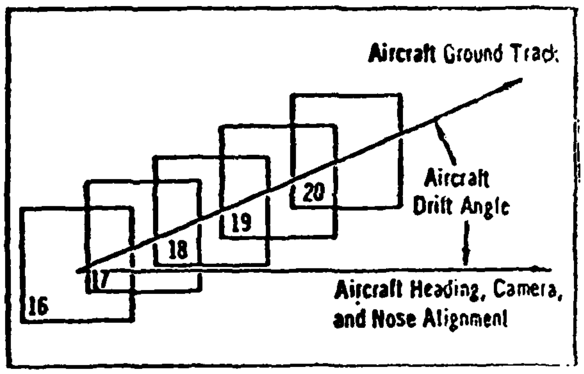
c. A complete monitored project log, or facsimile, that has been recorded by the imagery collection source and includes:

(1) Data on personnel involved.

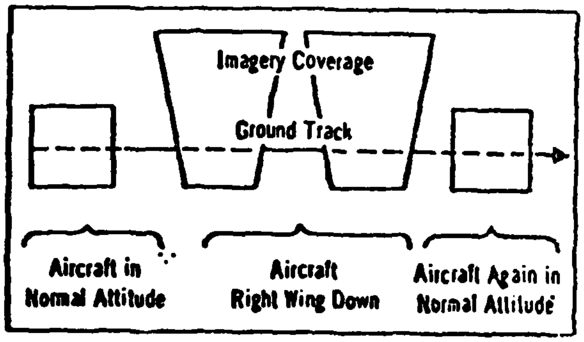
(2) Data on aircraft and sensors utilized in data collection.



a. Crab



b. Drift



c. Tip and tilt

Figure 34. Illustrations of effects of crab, drift, and tip and tilt of the aircraft

(3) Data on facilities and processes utilized in data handling.

(4) Data on daily activities during the mission including aircraft and sensor performance, weather conditions, notes on supplies used, etc.

137. It is evident from the preceding discussion that an evaluation process, if carried out in detail, is an exhaustive documentation of the mission parameters. Yet when this process is carefully planned and executed, the evaluation of the success in meeting mission objectives is greatly facilitated.

Processing data into final forms

138. When the final photographic products are made available for the working personnel, or even prior to this time, a decision must be made as to how the imagery will be cataloged and stored. This planning step should consider the following aspects if a set of imagery is to provide maximum information in the photointerpretation and/or mapping stages. A consideration of the factors discussed within this section on processing final data will yield positive results in achieving mission goals, within the restraints of the information presented by the imagery and the technical expertise of the working personnel involved.

a. The need for indexing photography.

b. The method of storing rolls and sheets of film or prints.

c. The availability of proper environments for handling imagery.

139. Indexing. An index may be the best method of documenting areas of coverage for a given mission, particularly when large quantities of imagery are involved. Indexes or plots show the relationship of each exposure to the others and to the project as a whole. Two types of indexes are ordinarily used: the line index or plot and the photo index.

a. The line index, prepared by the photographic units after the project is completed, consists of an overlay, usually keyed to a 1:250,000 scale map of the area, containing plotted lines showing the location and

identification of flights. Sometimes each picture, with its designating number, is plotted as a small square to scale. For most purposes, the exposure numbers shown at the beginning and end of each flight line are sufficient. If a break occurs in the flight, the exposure numbers at each break are shown on the chart. Gaps in photographic coverage are indicated graphically and clearly labeled. An explanatory legend is included in the margin.

b. Photo indexes are prepared after the photography is flown and accepted. In certain instances they are required as part of a project and the requesting agency specifies that the photographic unit prepare and furnish them with the aerial negatives. Usually, however, they are prepared by the requesting agency after receipt of the accepted aerial negatives. Contact prints made from the negatives are assembled, matched, and stapled to a board. Identifying numbers are usually pasted or stamped in the print corners. The assembly is then photographically reduced and a print from this negative constitutes the photo index. This type of index is useful for reconnaissance, area studies, control planning, field classification parties, geodetic control parties, indicating progress in map compilation by production elements, and ready location of specific photographs. A legend is shown on the index to explain location, roll numbers, dates of photography, flight altitudes, type and focal length of camera, and other pertinent information.

140. Storage. The storage of rolls and sheets of imagery must include the consideration of two major factors:

a. The method of storage must be logical and performed in a manner that will allow for a rapid and accurate retrieval of data in stored condition.

b. The method of storage must provide for conditions that will not result in degradation of the imagery quality (e.g., excessive moisture, heat, light, etc.) and will not require imagery that is not being utilized to undergo any additional handling other than that required to fulfill mission needs.

141. Generally roll films, if kept in closed cans when not in use and stored in protected cabinets in air-conditioned environments, will provide many years of working quality without deterioration. Sheet films may be stored in upright or horizontal formats, but must be kept in dust covers and flat whenever they are not being used. A minimum of

handling of film imagery will ensure that scratching by dust and deterioration of the emulsion by fingerprints and other foreign substances will be reduced. Print imagery can be easily stored by flight lines or other convenient units and arranged sequentially for filing in folders or envelopes within cabinets or on shelves. The WES has successfully stored several hundred 9- by 9-in. print photographs for this study by utilizing indexed manila envelopes that are filed by flight line and are stored in metal cabinets. Large quantities of data can be stored for reference in this manner and the system provides no difficulty in retrieving individual frame prints.

142. Working environment. A final consideration for imagery processing must account for the working environment in which the imagery will be used. Of the many sources of damage that imagery can be subjected to, by far the most destructive is dust and similar material that can scratch the emulsion. For best results in preventing dust problems, a specific location should be chosen wherein film handling and viewing are the primary activities. A regular regime for the work area should include each of the following:

- a. A habitual policy of maintaining a clean working space.
- b. A restriction of unnecessary traffic within the area.
- c. An air-conditioned source of ventilation (preferably with a slight positive pressure flow).
- d. Some form of filtering device to control the entrance of foreign matter.

PART V: APPLICATION OF PROCEDURES TO SELECTED REGULATED ACTIVITIES IN MOBILE DISTRICT

143. To demonstrate how some of the detection and monitoring procedures discussed in Parts III and IV of this report could be applied to regulated activities in the Mobile District, three example applications are included in this part of the report. The procedures for detection and monitoring of activities involving wetlands, water bodies, and structures were selected for demonstration purposes. The wetlands applications were directed toward the delineation of regulatory regions in and near the coastal regions of the Mobile District. The water bodies application was directed toward the use of Landsat digital data to locate water bodies of 10 acres or greater in size. The structures application was directed toward the development of a photointerpreters' catalog that can be used as a guide to familiarize new photointerpreters with the types of activities and structures most frequently occurring in the District.

Wetlands Applications

144. To assist the Regulatory Functions Branch in the task of processing permit applications and violation studies occurring within the Mobile District, it was determined that the location of their coastal wetlands and State-regulated coastal areas should be delineated on the latest aerial photography of these regions. The delineations were made by mapping the wetlands and regulated areas on overlays to the 1:62,500 photographic indices (mosaics) produced by Metro Aerial Surveys under project number DACW01-76-C-0162. The following discussion presents a brief summary of the pertinent State laws that affected the mapping of wetlands, the selection of criteria for mapping the mosaic overlays, the mapping of the wetlands and coastal regions of the Mobile District, the display of the mapped products, and a discussion of how the final products may be utilized in performing regulatory actions.

State laws affecting permit actions in coastal areas

145. The discussion of State laws contained in Appendix D presents a brief summary of legislation pertinent to the decisionmaking process in the granting of permits or evaluation of real or possible violations of the Corps permit program. The summaries are not intended to be taken as comprehensive, but rather as a selected list of source material from which further information may be obtained; however, care has been taken to ensure that the citations of laws are accurate and that comments represent the best available data provided to the WES during the course of this study.

Selection of criteria for mapping

146. A search was made by the WES during 1977 to collect all available information that could be used in mapping wetlands and regulated areas in the Mobile District along the Gulf Coast. The sources of information that were utilized were selected if they provided data for the following area (also see Figure 35).

- a. West to 89°45'W. longitude, or to the western edge of the Nicholson and Haaswood 7.5 topographic maps.
- b. South to the Gulf Coast and including the coastal islands along the Mississippi and Alabama shorelines.
- c. East to 87°15'W. longitude, or to the eastern edge of the West Pensacola and Fort Barrancos 7.5 topographic maps.
- d. North to a line following 30°30'N. latitude and including the area of Mobile Bay and the immediate vicinity.

147. Within the Alabama coastal area and the Mobile Bay area, the following sources of information were studied:

- a. USGS standard 1:24,000 and 1:62,500 scale topographic maps and advance line copy revisions or print orthophotomaps where available.
- b. USDA-SCS photo indices (1973-1974) for coastal counties at about 1:62,500 scale and aerial photographic prints of the coastal and Mobile Bay areas at about 1:24,000 scale.
- c. The atlas of 1:12,000 and 1:24,000 scale maps prepared by the Geological Survey of Alabama for the Alabama Coastal Marsh Inventory.[19]

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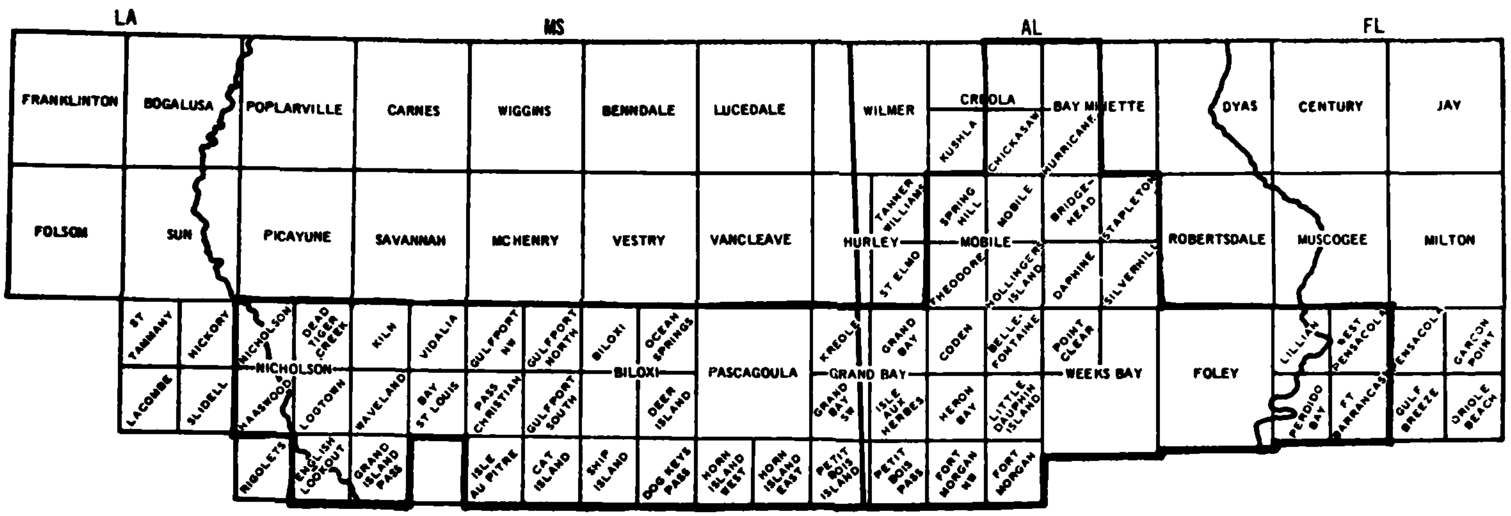

Figure 35. Areas of Mobile District mapped for coastal wetlands and state regulations

d. The atlas of 1:24,000 and 1:62,500 scale maps prepared by the Marine Environmental Sciences Consortium for the Atlas of the Ecological Habitats of Coastal Alabama.[20,21]

e. Standard NOAA coastal navigation charts for Alabama at 1:80,000 scale.

f. Data from the Alabama section of the Cooperative Gulf of Mexico Estuarine Inventory (1971-1972).[22,23]

g. Data from The Environment of Offshore and Estuarine Alabama prepared by the Geological Survey of Alabama (1974).[24]

h. Data from the Shoreline and Bathymetric Changes in the Coastal Area of Alabama prepared by the Geological Survey of Alabama (1976).[25]

i. The Alabama Legal Code and particular reference to Act No. 534 of the 1976 legislature.[26]

j. The map of the coastal area of Alabama prepared by the Alabama Coastal Area Board (1976).[27]

k. CIR imagery of the Alabama coast flown by NASA (mission 354, 3-22-77) through contract with the WES.

148. The Mississippi coastal area was mapped utilizing information from the following sources:

a. USGS standard 1:24,000 and 1:62,500 scale topographic maps and advance line copy revisions or print orthophotomaps where available.

b. USDA-SCS photo indices (1969-1970) for coastal counties at about 1:62,500 scale.

c. Wallace Aerial Survey 1976 photo indices and photographic film positives (at 1:24,000 scale) of the Mississippi coast.

d. Atlas of coastal wetlands photomaps at 1:24,000 scale prepared by the Mississippi Marine Resources Council (1973).[28]

e. Marsh areas of Mississippi as presented in the Cooperative Gulf of Mexico Estuarine Inventory and Study (1973).[29]

f. Data on Sixteenth Section and Lieu Lands from the Mississippi Forestry Commission and the State Land Office.

g. The Mississippi Legal Code and changes during 1975-1977.[30]

The roll film positives and contact prints at 1:24,000 scale provided by the Metro contract were used throughout the study for areas in both Mississippi and Alabama.

149. Louisiana coastal areas were not mapped upon the mosaics because:

- a. The area of land within the regulatory boundaries of the Mobile District is very small and presents considerably fewer problems in determining locations of concern to the permit programs.
- b. The present status of the Louisiana coastal law (see Appendix D, paragraph 15) precludes the organization of mapped details in the format shown for Alabama and Mississippi.

Categories of information utilized in constructing mosaic overlays

150. After the sources of mapping information had been assembled, the categories of information to be included on the mosaic overlays were selected. Two primary groups of information were chosen, based upon their relevance to the regulatory functions of the permit programs in the Mobile District. The two primary groups, that overlap in many areas, were wetlands on or near the coast and coastal areas regulated by State legal codes.

151. Marshes and swamps. The wetlands lying on or near the Mississippi and Alabama coasts were designated as marshes or swamps when information from other sources existed (see paragraphs 146-148)or the photographic images indicated the presence of potential extensions of wetland habitats (e.g., in the case of dendritic drainage patterns that joined with identified wetlands). The delineations thus produced attempted to follow the botanical definitions of a marsh as an open, treeless, meadow-like or tussocky, saltwater or freshwater tract of wet or spongy land, usually with occasional open shallow pools of water and with a vegetation of more of less dense, erect, aquatic or amphibious plants including cattails, grasses, sedges, reeds, rushes, or other succulent herbs (cf. MIL-STD-1165[31]). A swamp was identified characteristically as an area of continuously saturated ground, supporting large aquatic plants having submerged or floating leafy shoots, often dominated by shrubs and trees

(cf. MIL-STD-1165[31]). The WES did not try to classify coastal wetlands, but rather transferred the information that had been produced by state and private organizations onto the photomosaic overlays. Those wetlands which were typically extensions of identified marshes and swamps were indicated on the overlays as a separate class in purple (see paragraph 157) to denote their potential importance in the regulatory functions of the Mobile District. The Regulatory Functions Branch Should consider extending its in-the-field site inspections of permit applications that occur within this category.

152. Coastal zones. The coastal zones in Mississippi and Alabama represent legally defined portions of land within which many activities of business or private life are regulated and/or permitted by one or more designated State agency.[32,33] The restrictions placed by the State upon activities within these coastal zones must be considered by the Corps regulatory personnel for compliance with Title 33 of the Code of Federal Regulations, Part 320 - General Regulatory Policies, Section 320.4 - General Policies for Evaluating Permit Applications. Within this section, subheading (h) - "Activities Affecting Coastal Zones" declares that: "Applications for the Department of the Army permits for activities affecting the coastal zones of those states having a coastal zone management program approved by the Secretary of Commerce will be evaluated with respect to compliance with that program... ."[34]

153. The coastal zone in Alabama was officially defined by State Act 534 of 1976 as follows:

> "Begin at the southernmost point on the Mississippi-Alabama state line where the land surface elevation reaches 10 feet above mean sea level and continue in a general easterly direction along the 10-ft contour to the proximity of Mobile Bay; continue in a northerly direction on the 10-ft contour along the western shore of Mobile Bay and the Mobile River delta to the north line of Mobile County; thence southeastward along the north line of Mobile County to the intersection with the Baldwin County line in the Mobile River; thence along the west and north lines of Baldwin County in the Mobile and Alabama Rivers to the intersection of the southwest corner of Monroe County; thence eastward along the Baldwin County line to the intersection of the westernmost point of Baldwin County where the land surface altitude reaches 10 ft above mean

sea level; thence along the 10-ft contour in a southwesterly and south direction along the Alabama River, the Mobile River delta and the east shore of Mobile Bay to the proximity of Bon Secour; then continue along the 10-ft contour in an easterly and northeasterly direction to the Alabama-Florida state line."[26]

154. For Mississippi, the coastal areas of the state lying within regulatory boundaries are defined by the Coastal Wetlands Protection Law of 1973 and will be strengthened by the 1978 Senate bill described in Appendix D:

a. "Coastal wetlands" means all publicly owned lands subject to the ebb and flow of the tide; which are below the watermark of ordinary high tide; all publicly owned accretions above the watermark of ordinary high tide and all publicly owned submerged water-bottoms below the watermark of ordinary high tide.

b. The term "coastal wetlands" shall be interpreted to include the flora and fauna on the wetlands and in the wetlands. They were mapped according to the boundaries indicated in the Mississippi Marine Resource Council's Atlas of Coastal Wetlands Photomaps.[28]

155. Other State-regulated areas and boundaries. Included in the mosaic overlay information were three minor categories that were added to aid District personnel in the use of the displays. The first category was the Sixteenth Section lands that appeared within the area covered by the mosaics. Lieu lands were not mapped due to the many small tracts of land involved and the irregular nature of many of the designated areas. The locations of these lieu lands can be determined from the lists given in Appendix D.

156. The second minor category was the set of lines indicating the state boundaries for Mississippi and Alabama. The last category represented lines indicating the approximate areas of coverage of the topographic maps shown on each mosaic set, or indicated areas within the field of the mosaic where significant mismatching of the flight line frames occurred and resulted in a discontinuous presentation of the mapped information.

Color codes employed to depict information categories

157. Early in the development of a plan for the presentation of the

coastal wetlands and regulated areas, it was decided that a color-coded system showing the different information categories would provide the most readable means for interpreting the overlay data. Permanent felt tip markers were used to draw the overlays and the following color code was used throughout the mapping:

- a. Red - coastal zone areas, offshore islands, parks, or national seashores that are regulated by State or Federal agencies.
- b. Blue - swampy regions within the coastal areas of coverage.
- c. Green - marsh regions within the coastal areas of coverage.
- d. Yellow - Mississippi Sixteenth Section lands lying within the coastal areas of coverage.
- e. Orange - state boundary lines.
- f. Purple - areas within the coastal coverage showing potential wetland characteristics that should be considered when permit actions are involved.
- g. Black - registration marks (+) for aligning overlays with mosaics. Solid lines show boundaries of topographic map coverage and unmatched photography.

Mapping of the wetlands and coastal regions of the Mobile District

158. To accomplish the task of mapping the coastal wetlands and State-regulated coastal areas of the Mobile District, the WES undertook an evaluation of several commercially available tools for transfer of cartographic and photographic information onto the mosaics. It was decided that, in terms of cost, portability, and applicability to future needs, the Bausch & Lomb Zoom Transfer Scope (ZTS), Model ZT4-H (Figure 36), would be selected for use in the present study. This unit was a satisfactory aid in the task of preparing the mapped mosaic products and should provide a strong support role to the future monitoring program needs of the Regulatory Functions Branch.

159. Use of the Zoom Transfer Scope. In many aspects, the use of the ZTS entails no greater difficulty than that encountered through the use of any binocular optical magnifying system. The instruction manual and supplemental folders provided by Bausch & Lomb are clearly written

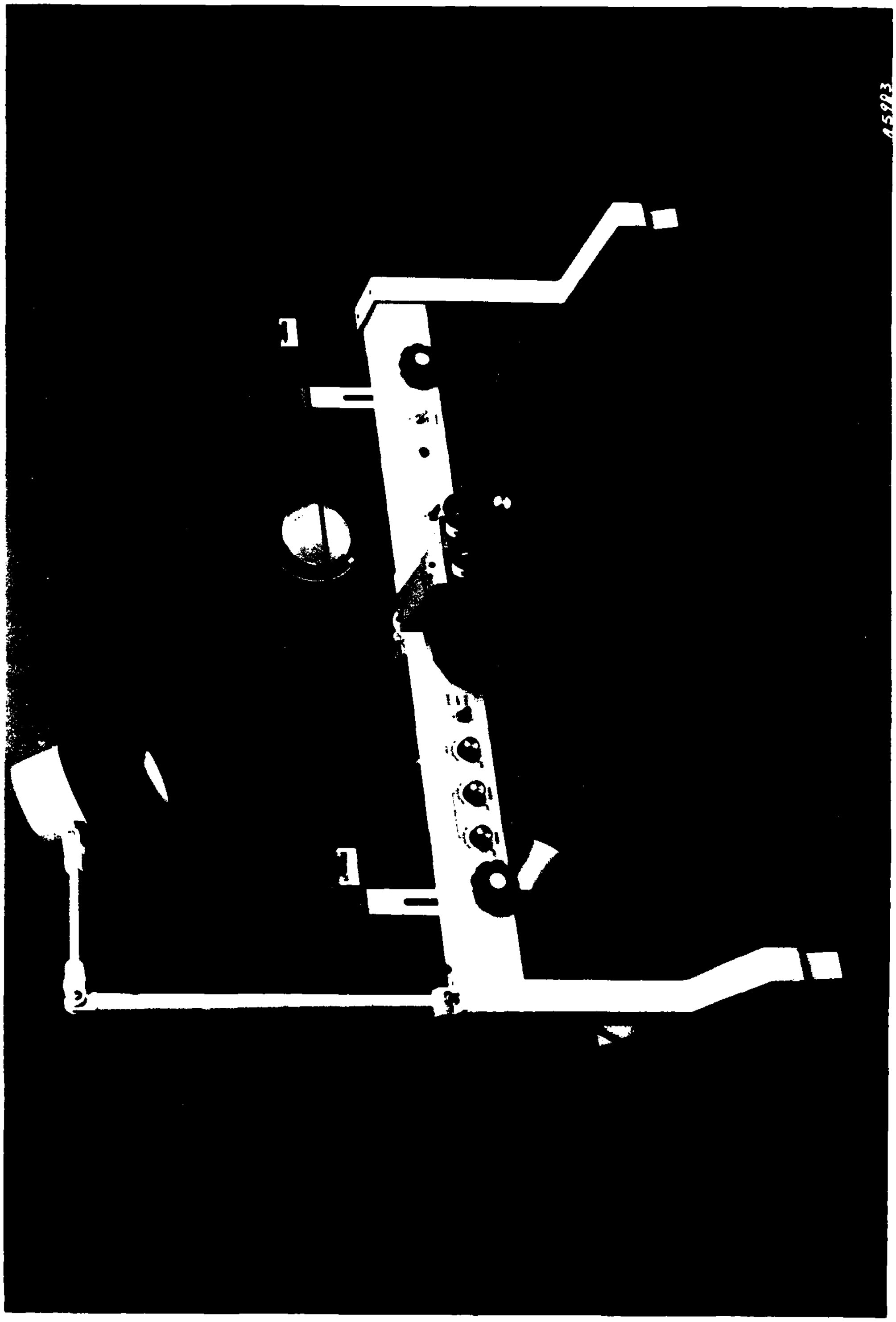

Figure 36. Bausch and Lomb Zoom Transfer Scope, Model ZT4-H

and well illustrated. The WES personnel found that relatively untrained individuals were capable of self-instruction with these materials and. were able to attain a high level of working accuracy within a few days after beginning to use the scope in mapping efforts.

160. Suggested supplies and modifications. For the maximum utilization and working life of the ZTS, there are several points of instruction that all users should be made aware of. The most important point is that of maintaining cleanliness of the scope and the working environment of the instrument. As in the case of any tool utilizing optical systems, extreme effort should be made to avoid contamination of the optical surfaces with foreign objects containing oils, solvents, or dust from the environment. The lenses and other working surfaces are highly susceptible to scratching and a routine program of proper cleaning and covering the instrument when not in use is necessary. The instrument should be placed in a protected area and moving of the unit should be discouraged. Cleaning should be attempted only by persons who are thoroughly familiar with correct procedures and who have consulted the instruction manual and maintenance product directions.

161. During the course of the present study, the WES made some modifications to the basic scope unit that better suited the mapping needs of this project and those of the District personnel in the future. The most significant change was made to answer the problem of handling roll film upon the upper glass stage. The unit as supplied by Bausch & Lomb does not provide for handling roll film. However, since much of the monitoring and mapping information that is or will be used is extracted from aerial roll photography, the capability for handling this data source was added by the WES. A very satisfactory roll film viewing assembly was produced for the WES by Mr. Clyde E. Renz of the Rock Island District, CE. The assembly is shown in Figures 37 and 38 and utilizes reel brackets, roller assemblies, and bracket guides produced by the Richards Corporation, McLean, Virginia. The cost for parts to construct the assembly is less than $300.00 (excluding labor), and the finished assembly provides a highly useful means for bidirectional handling of data in roll form.

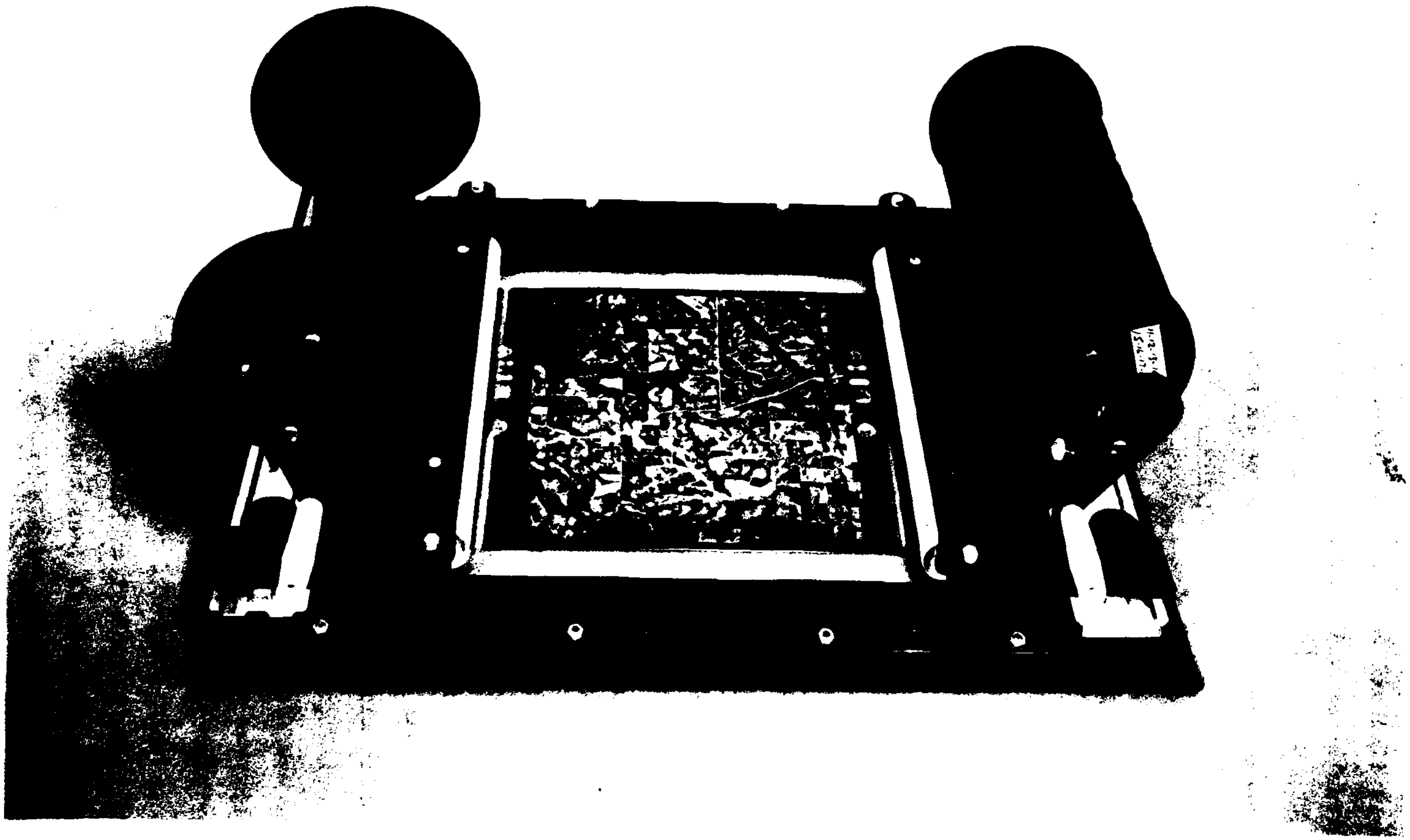

Figure 37. Zoom Transfer Scope roll film viewing assembly

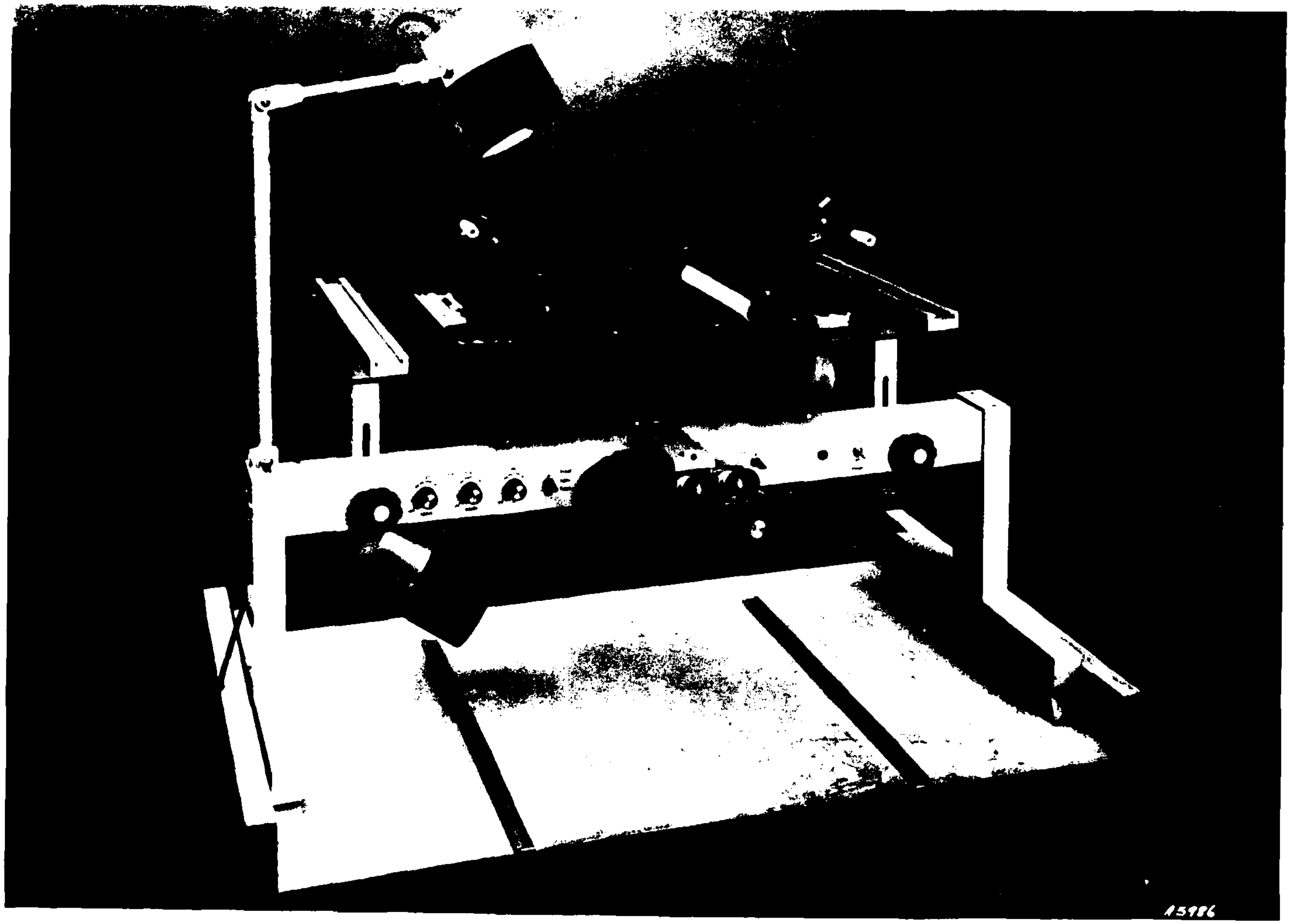

Figure 38. Roll film viewing assembly in place on upper stage of Zoom Transfer Scope

162. In addition to the assembly by Mr. Renz, the WES modified the upper glass stage by having four holes drilled through the plate glass to accept mounting screws. These may be used to produce a more permanent roll film assembly if additional brackets, rollers, and bracket guides are obtained from the Richards Corporation in the future.

163. An addition to the scope was the construction of a retaining platform for the base of the stand legs. This unit, shown in Figure 39, helps restrict any movement of the scope on the working surface without interfering with the operator's functions. The materials are basically plywood, 2- by 4-in. lumber, wood screws, and glue, and cost only a few dollars from most local building suppliers.

164. Limitations encountered in use of the ZTS. During the course of the study, the ZTS performed well and only few serious problems in operation were encountered. A few points of minor concern are described here to aid future users of the instrument.

- a. The optical system does produce some eye strain for operators, and it is felt that working periods for an individual should not exceed 1 or 2 hr without a break period. Working periods of longer duration may cause eye soreness and possibly headaches.
- b. The focusing concurrently of the upper stage image with the material on the lower drawing surface was not felt to be as precise as might be possible from an instrument of this type. While significant focusing problems did not occur, it was found in most instances that slight intermediate settings between the best image on the upper stage and the material on the drawing surface were required. Normally, this approach produced a fairly workable compromise.
- c. Most of the mechanical features of the scope performed as described and provided no maintenance problems. The zoom control, however, which is utilized probably more than any other single control, did develop some play in the mechanism. Removal of the upper shroud for the optics unit and slight tightening of the zoom mechanism did alleviate most of this problem temporarily.

Display of mapped wetland products

165. The completed coastal mosaics with the plastic overlays required an appropriate form of display to allow for maximum utilization of the information, provide for protection of the mosaics and other

Figure 39. Zoom Transfer Scope leg base

displayed documents, and offer the best means of moving the displays to locations other than the Mobile District Regulatory Functions Branch Office. Several formats for the display and storage of large photographic and mapped material were considered with the above features employed to judge the best utility of the several products currently available.

166. Selection of panels. The final display medium that was selected was a vertically supported series of lightweight panels on a movable stand (Figure 40). The unit was built by the welding and carpentry shops of the WES, and provides for rapid and easy viewing of large quantities of displayed information. The selected panel frames, marketed by Magna Plan Corporation, Champlain, New York (Catalog No. 09914248V), are 42 in. wide by 48 in. tall, providing nearly 14 sq ft of viewing area per panel side. A foam-core panel insert (Catalog No. 912150) for each panel frame was selected for the lightweight feature and the ease with which displays could be attached to the inserts.

167. Mounting of mosaics depicting wetlands and coastal regulated areas. The 1:62,500 scale mosaics with their acetate overlays were mounted on the sides of the foam-core panel inserts as shown in Figure 41. This arrangement provided for a total area of coverage on each panel side equal to four 1:62,500 (or sixteen 1:24,000) scale quadrangle maps of the USGS topographic format. The coverage of the Mississippi and Alabama coastal areas described in paragraphs 153 and 154 required four panel sides (or two complete panels). The presentation of the information was designed to proceed from the western edge of Mississippi on the first side and then generally easterly toward the Alabama and Florida state lines on succeeding sides.

168. The four mosaic units on each panel side were reinforced by mounting the photographs to heavy poster board. This backing added additional support to the entire panel surface. Each mosaic unit displayed on a panel side was indicated by line marks on a corresponding area of a locator map of the entire mapped area of the coast. The locator maps were designed to show the identical series of USGS topographic maps, by name, displayed on the mosaics. This would allow rapid reference of the mosaic information areas with existing and

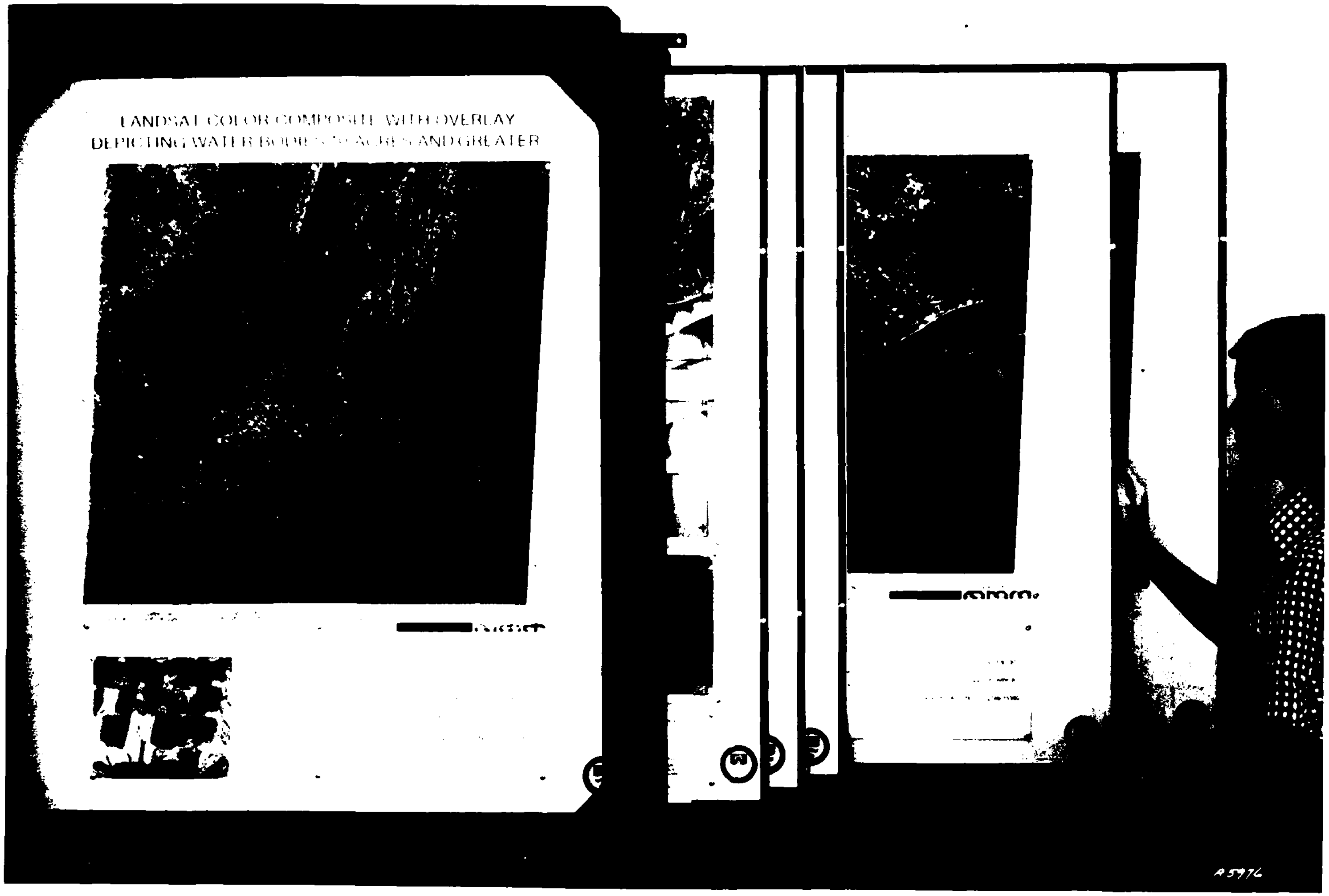

Figure 40. Display stand used to mount aerial mosaics and Landsat overlays

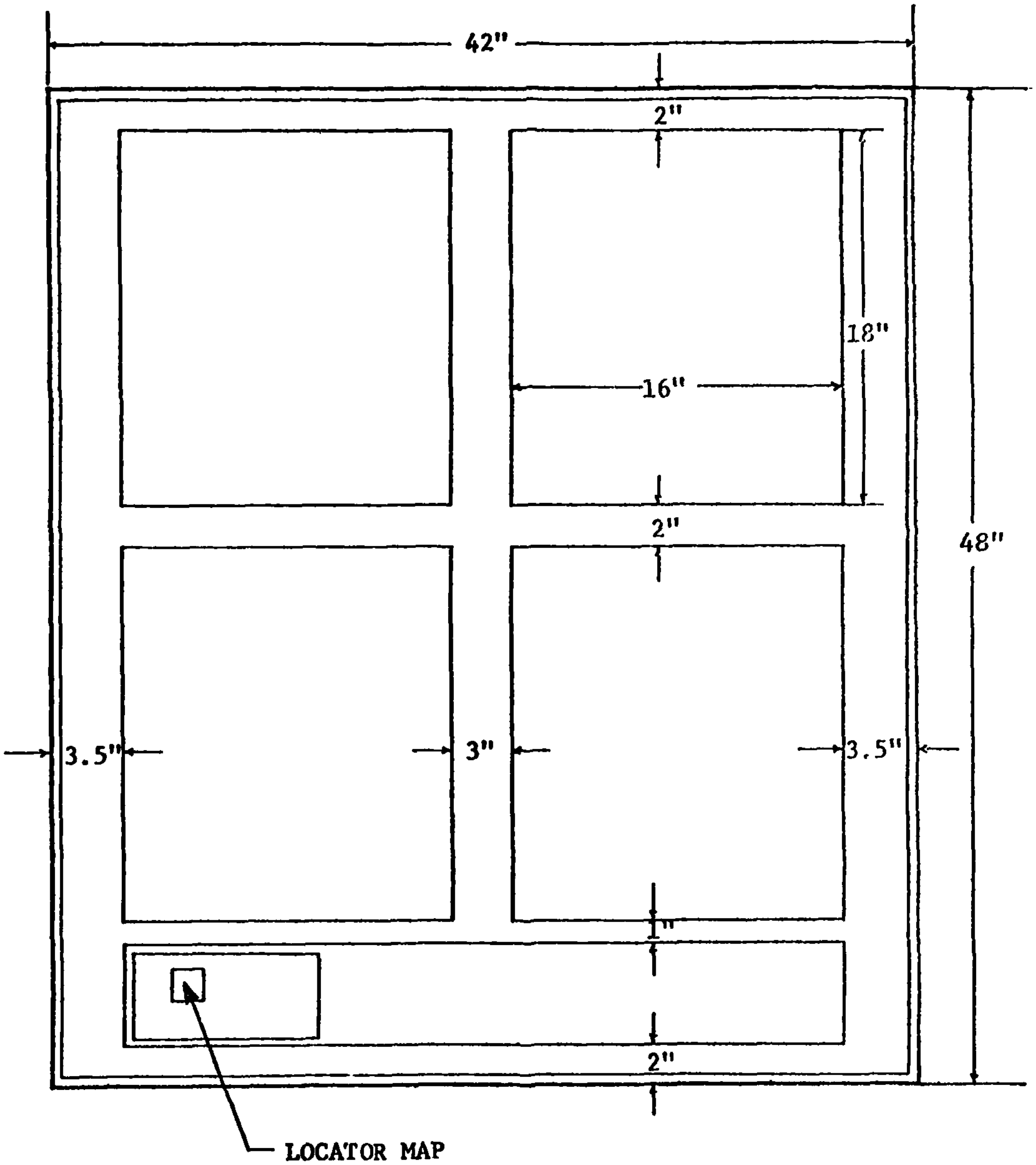

Figure 41. Format of mosaics on display panels

forthcoming revisions of the topographic maps, and allow for rapid gathering of coordinate and related data for permit actions carried on by the Regulatory Functions Branch.

169. Use of panel displays in regulatory functions. The design and construction of the mosaic overlay displays were accomplished with the intended aim of providing the Regulatory Functions Branch personnel with a readily useable and easily readable source of coastal area information. As permit applications or violation studies are processed by office personnel, the mosaic overlays will provide a quick reference for coastal wetlands and state regulations that may affect a regulatory decision. After the location of the activity in question has been determined, the corresponding print for the flightline frame may be pulled from the files and examined for closer detail or used by the field inspection teams for on-site studies.

170. The construction of the mosaic panels in the format described earlier will allow for rapid extraction of information and storage of data with a minimum loss of working space. Individual panels or the entire display unit will be able to be transported for public demonstrations or briefings required by Division or other official authorities.

Water Body Application

171. The Regulatory Functions Branch is responsible for permitting discharges of dredged or fill material into lakes 10 acres and greater including their adjacent wetlands. This requirement by the FWPCA can be fulfilled provided, of course, that the locations of these water bodies are known. This all too often is not the case, however, since the normal source of this information (i.e., topographic maps) is not always current nor is it always sufficiently accurate in its portrayal of lake areas. This presented a problem to the Mobile District.

172. The solution to the problem suggested by the WES was to inventory all water bodies including streams and rivers using the water-detection capabilities of Landsat. Since the detection of water bodies can be accomplished with a high degree of certainty using Band 7 digital data, the WES proposed that overlays to the 1:250,000 false color

composites (available from the EROS Data Center) be produced depicting all water bodies 10 acres and greater including rivers and streams. In addition to the overlays, the inventory would include a summation of surface area of the lakes and rivers for Mississippi, Alabama, Georgia, and Louisiana.

Acquisition of data

173. The decision to inventory water bodies in the Mobile District necessitated a search by the EROS Data Center for the best digital data. Three factors constrained the search: cloud cover, quality of data, and time of year. The Center was requested to initiate a search for all current (1975 to present) Landsat scenes within the Mobile District. The search was constrained by a maximum cloud cover of 10 percent, a minimum data quality of 5, and a time frame of winter months. The winter months of December, January, and February were selected because the edges of water bodies are less likely to be concealed by fully developed tree canopies during this time of year.

174. The search revealed that the most recent scenes conforming to the above constraints fell within a time frame between 21 January and 25 February 1977. The scenes selected for use are listed in Table 23. A mosaic of these scenes was assembled and is shown in Figure 42. The numerals on each picture of the mosaic correspond to the scene numbers in Table 23.

Preparation of overlays

175. A special computer program called LAKES was developed to determine the location of water bodies 10 acres and greater. The program first examined band 7 of each pixel of an entire Landsat scene and classified each as water or other. The classification criteria (i.e., threshold value) for water was 3. That is, if the band 7 value for a given pixel had a radiance value of 3 or less, it was classified as water. The program then "looked" at the neighboring pixels surrounding a given water pixel to determine whether or not that pixel belonged to a group of 9 or more contiguous pixels. If it did, the computer tagged that pixel as part of a lake or stream and moved on to the next water pixel. As the program scanned the entire Landsat array for the

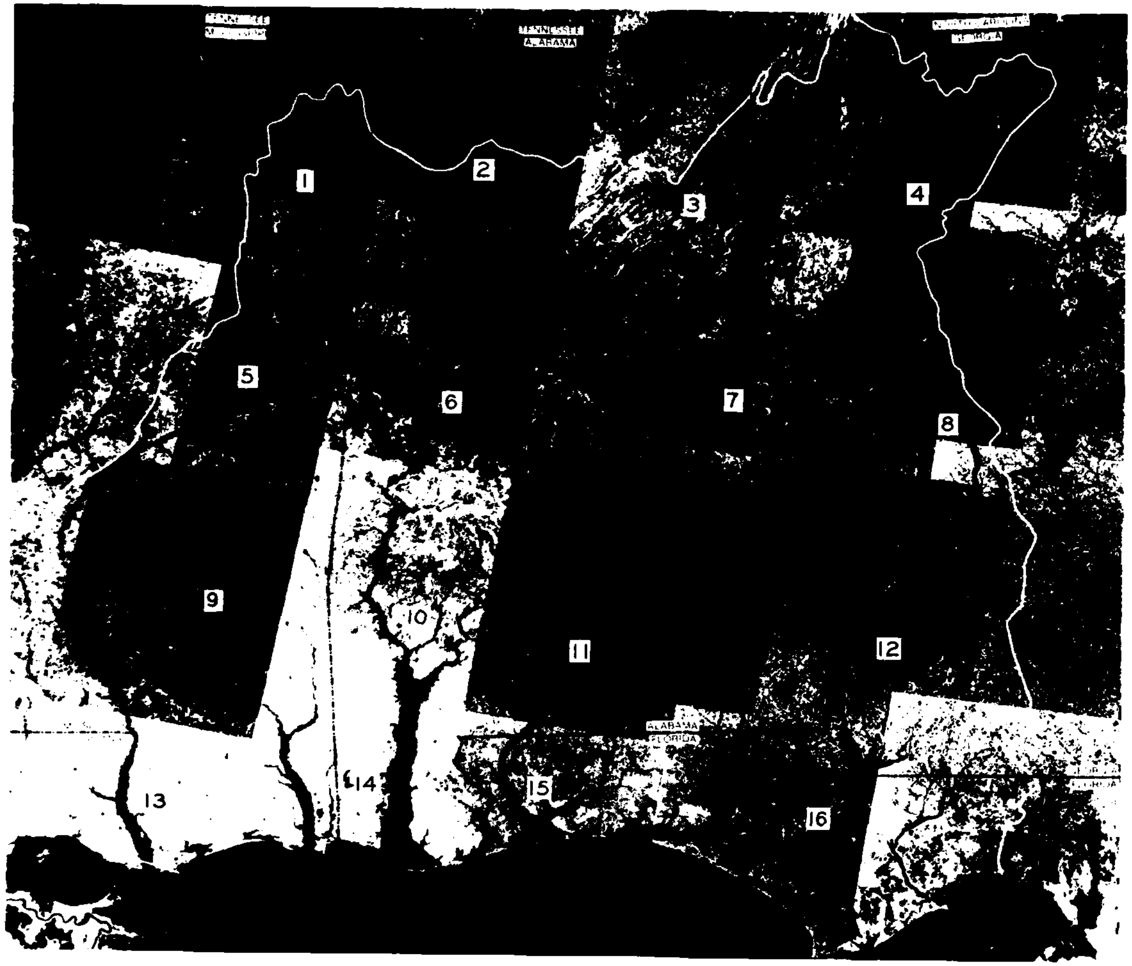

Figure 42. A mosaic of the Landsat scenes used to inventory water bodies 10 acres and greater

second time, it produced a magnetic tape with the location information for each tagged pixel. This tape was then read by the Optronics film reader/writer (Appendix A) and a 6.5- by 6.75-in. black-and-white transparency was generated. The transparency contained the images of the lakes and streams within the Landsat scene, where the water pixels had been left clear and all other pixels colored black.

176. A transparency was produced for each of the 16 Landsat scenes composing the entire Mobile District. They were then enlarged photographically to an approximate scale of 1:250,000 that would approximately overlay the 1:250,000 color composites produced by the EROS Data Center. Since the WES's procedure for removing the distortion caused by the earth's rotation was different from the EROS Data Center's procedure, the overlays could not be made to overlay perfectly. However, the match was very close and there was no problem in determining the location of water bodies in the color composites.

177. The enlarged transparencies were used to produce the final colored overlay transparencies (blue for water and clear for other) by the Diazo process. These overlays were then mounted on the color composites and the two together were mounted on the same type of display panels previously discussed in paragraph 166.

Determination of total areas of water bodies

178. The task of obtaining a total surface area of water for both lakes and streams in each State of the Mobile District was not performed by the computer directly from the CCT's since all 16 scenes of the District overlapped one another and some extended beyond the boundary of the District. To avoid the problem of double bookkeeping, the boundaries of the District and States were transferred manually onto the 6.5- by 6.75-in. transparencies using the ZTS. The portions of each scene that either overlapped another scene or were outside the boundary were blacked out. The transparencies were then scanned by the Optronics film reader/writer, and the sum of areas of all the lakes and streams was determined (Table 24).

Structure Application

179. To satisfactorily monitor permit-related activities within the jurisdictional areas of the Mobile District, routine remote reconnaissance of some form must be performed over these areas. It has been indicated in Part III of this report that part of the required reconnaissance can be performed by Landsat. That is, using Landsat imagery at a scale of 1:250,000, one can probably detect large changes in wetlands caused by improper disposal of dredged material onto the wetlands or clearing of trees from wetlands. However, smaller activities or structures such as piers, boatdocks, boatslips, etc., cannot be monitored using Landsat. The high cost of operation and data handling of MSS data also prohibits the use of this system as a monitoring system. In addition, field teams or ground crews and on-site surveillance techniques are too costly and time consuming to perform routine monitoring of small activities. Thus, of the three types of remote sensing methods discussed in this report, only aerial photography can adequately perform the task of monitoring small activities.

180. The selection of aerial photography as the source of remotely acquiring data for monitoring purposes implies the need to accurately interpret the data presented in photographic form. This carries with it the requirement of obtaining photointerpreters to interpret the data and ground-truth data to increase the reliability of the photointerpretation.

181. The problem inherent in these two requirements is the need to rapidly train personnel to become photointerpreters and to familiarize them with the types of structures and activities that require CE permits. To that end, the WES has developed a photointerpreters' catalog that will satisfy both requirements.

182. The catalog (Appendix E) is constructed of photographs of activities and structures comprising the majority work load of the District. The examples selected for presentation occur along the flight line shown in Figure 2. Both aerial and ground photographs of various activities and structures are presented. By studying this catalog and

making repeated comparisons between ground and aerial photography, one should become very adept at recognizing these same features in the photography flown to monitor the District.

PART VI: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

183. On the basis of this study, the following conclusions were reached.

a. Within the scope of work usually performed by the Mobile District, Landsat can probably best be applied as a tool for change detection.

b. Landsat imagery at a scale of 1:250,000 is sufficient for detecting 10-acre or greater changes in wetlands caused by disposal of fill material or clearing of trees.

c. Landsat data cannot be used to detect Section 10 activities such as boathouses, docks, piers, etc. Even the proposed Landsat D, which will have a smaller resolution element, cannot detect these types of activities.

d. Water-land interfaces and water bodies 2 to 3 acres and greater can be reliably detected using Landsat data.

e. Imagery produced from Landsat is very economical to use. The costs of black-and-white and color imagery produced by the EROS Data Center at a scale of 1:250,000 are $0.0015 and $0.0076/square mile, respectively. The costs of these same products produced by the WES are $0.0227 and $0.0431/square mile, respectively.

f. The high cost of obtaining and processing MMS data prohibits its use by the District for routine monitoring. Only at an altitude of 12,000 ft does the cost approach that of conventional photography but the resolution is too poor for locating small activities.

g. Color composites duplicating color IR imagery can be produced from bands 4, 6, and 9 of the MMS data.

h. The MMS system can probably best be applied to the task of obtaining reflected radiance data for the purpose of supplying feature background signatures to the PSSM. This source of ground-truth data would eliminate the need for acquiring the data via field teams and has the advantage of seeing the ground features from the same vantage point as the aerial cameras.

i. Interpretation for specific data can be enhanced by selection of the optimum film and filter combination. That is, selection of types of film and filters to acquire optimum results from a photographic remote

sensing mission should be made on the bases of results generated by the PSSM.

j. For the majority of the activities requiring detection by remote means, color IR photography is the optimum imagery for acquiring data. The choice of color IR photography as the best individual imagery type is based on its superiority throughout the evaluation of film types conducted in the photointerpreters' catalog.

Recommendations

184. Based on this study, it is recommended that:

a. Further study be supported to develop automatic detection and classification techniques to detect and interpret CE permit-related activities using MMS data.

b. Further study be supported to determine the capabilities of Landsat D to monitor wetlands.

REFERENCES

1. Struve, H., Grabau, W. E., and West, H. W. 1977. "Acquisition of Terrain Information Using Landsat Multispectral Data; Correction of Landsat Spectral Data for Extrinsic Effects," Technical Report M-77-2, Report 1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

2. __________. 1977. "Acquisition of Terrain Information Using Landsat Multispectral Data; An Interactive Procedure for Classifying Terrain Types by Spectral Characteristics," Technical Report M-77-2, Report 2, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

3. Grabau, W. E. 1976. "Pixel Problems," Miscellaneous Paper M-76-9, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

4. Kennedy, J. G., and Williamson, A. N. 1976. "A Technique for Achieving Geometric Accordance of Landsat Digital Data," Miscellaneous Paper M-76-16, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

5. Williamson, A. N. 1978. "Innovations in Digital Image Processing," Miscellaneous Paper M-78-4, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

6. National Aeronautics and Space Administration. 1976. "Landsat Data Users Handbook," Document No. 76SDS4258, Goddard Space Flight Center, Greenbelt, Md.

7. Williams, R. S., and Carter, W. D. 1976. "ERTS-1, A New Window On Our Planet," Geological Survey Professional Paper 929, U. S. Government Printing Office, Washington, D. C.

8. Link, L. E. 1974. "The Use of Remote Sensing Systems for Acquiring Data for Environmental Management Purposes; A Procedure for Predicting Image Contrasts in Photographic Remote Sensor Systems," Technical Report M-74-8, Report 1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

9. Link, L. E. 1978. "Procedures for the Systematic Evaluation of Remote Sensor Performance and Quantitative Mission Planning," Technical Report M-76-8, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

10. May, J. R. 1978. "Guidance for Application of Remote Sensing to Environmental Management, Appendix A: Sources of Available Remote Sensor Imagery," Instruction Report M-78-2, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

11. __________. 1978. "Guidance for Application of Remote Sensing to Environmental Management, Appendix B: Sources of New Imagery Missions." Instruction Report M-78-2, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

12. Shamburger, J. W., and Woods, H. K. 1975. "Application of Remote Sensors to Army Facility Management, Appendix B, Validation of Environmental Maps Produced Through Air-Photo Interpretation," Technical Report M-74-2, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

13. Estes, J. E., and Simonett, D. S. 1975. "Fundamentals of Image Interpretation," Manual of Remote Sensing, Chapter 14, Vol 2.

14. Avery, T. E. 1970. "Photointerpretation for Land Managers," Publication No. M-76, Eastman Kodak Company, Rochester, N. Y.

15. Headquarters, Department of the Army. 1963. "Photogrammetric Mapping," Engineer Manual EM 1110-2-1000, Washington, D. C.

16. Link, L. E., Jr. "Sensitivity of Normalized Classification Procedures for Floodplain Soils" (to be published), Pennsylvania State University, State College, Pa.

17. Link, L. E., Jr., and Stabler, J. R. 1976. "The Use of Remote Sensing Systems for Acquiring Data for Environmental Management Purposes; A Nomogram for Computing Optical Density Contrast," Technical Report M-74-8, Report 3, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

18. Headquarters, Department of the Army. 1970. "Cartographic Aerial Photography," Technical Manual TM 5-243/AFM 95-6, Washington, D. C.

19. Geological Survey of Alabama. 1976. "Alabama Coastal Marsh Inventory, University of Alabama, Ala."

20. Vittor, B. A., and Stout, J. P. 1975. "Delineation of Ecological Critical Areas in the Alabama Coastal Zone," Report No. 75-002, Marine Environmental Sciences Consortium, Dauphine Island, Ala.

21. __________. 1975. "Delineation of Ecological Critical Areas in the Alabama Coastal Zone; Appendix B: Atlas of the Ecological Habitats of Coastal Alabama," Report No. 75-002, Marine Environmental Sciences Consortium, Dauphine Island, Ala.

22. Swingle, H. A. 1971. "Biology of Alabama Estuarine Areas-Cooperative Gulf of Mexico Estuarine Inventory," Alabama Marine Resources Bulletin, No. 5, pp 1-123.

23. Crauce, J. H. 1971. "Description of Alabama Estuarine Areas - Cooperative Gulf of Mexico Estuarine Inventory," Alabama Marine Resources Bulletin, No. 6, p 185.

24. Geological Survey of Alabama. 1974. "The Environment of Offshore and Estuarine Alabama," Information Series 51, University of Alabama, Ala.

25. Geological Survey of Alabama. 1976. "Shoreline and Bathymetric Changes in the Coastal Area of Alabama - A Remote Sensing Approach," Information Series 50, University of Alabama, Ala.

26. Code of Alabama, 1975 (as rewritten October 1977).

27. Alabama Coastal Area Board. 1976. "A Map of the Coastal Area of Alabama," Alabama Development Office, State Planning Division, Montgomery, Ala.

28. Mississippi Marine Resources Council. 1973. "Atlas of Coastal Wetlands Photomaps," Jackson, Miss.

29. Mississippi Marine Conservation Commission. 1973. "State of Mississippi Gulf Coast Research Laboratory - Cooperative Gulf of Mexico Estuarine Inventory and Study," Jackson, Mississippi, Ed. J. Y. Christman.

30. The Harrison Company. 1972. "Mississippi Code of 1972, Annotated and 1976 Cumulative Supplement," Atlanta, Ga.

31. U. S. Department of Defense. 1977. MIL-STD-1165, "Report to the Congress on Coastal Zone Management," Public Law 92-583, Fiscal Year 1976, National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, Washington, D. C.

32. U. S. Department of Commerce. 1976. "State Coastal Zone Management Activities 1975-1976," Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, Dec 1976. Washington, D. C.

33. "Coastal Zone Management Act of 1972," Public Law 92-583, 86 Stat. 1280; approved 27 Oct 1972.

34. Federal Register, "Regulatory Program of the Corps of Engineers," Tuesday, 19 Jul 1977, Part II, Office of Federal Register, Washington, D. C.

35. Headquarters, Department of the Army. 1969. "Map Reading," Field Manual FM 21-26, U. S. Army AG Publication Center, Baltimore, Md.

36. __________. 1973. "Universal Transverse Mercator Grid," Technical Manual TM 5-241-8, U. S. Army AG Publication Center, St. Louis, Mo.

37. __________. 1958. "Universal Transverse Mercator Grid Tables for Latitudes 0°-80°; Clarke 1866 Spheroid; Transformation of Coordinates from Geographic to Grid," Technical Manual TM 5-241-4/1, Vol I, U. S. Army AG Publication Center, St. Louis, Mo.

38. __________. 1958. "Universal Transverse Mercator Grid Tables for Latitudes 0°-80°; Clarke 1866 Spheroid; Transformation of Coordinates from Grid to Geographic," Technical Manual TM 5-241-4/2, Vol II, U. S. Army AG Publication Center, St. Louis, Mo.

39. Mississippi Marine Resources Council. 1976. "Coastal Zone Management of Particular Concern and Priority of Uses," MASGP-76-029.

40. Craig, F. 1978. "Summary of Louisiana Revised Statutes of 1950," Louisiana State University, Baton Rouge, La.

41. Code of Georgia, 1977 Session.

Table 1

Types of Permit Activities Occurring in the Mobile District

GROUP 1: Bank and Shore Protection Structures

1. Single-component revetment
   a. Stone riprap
   b. Concrete block
   c. Tetrapod
   d. Sack revetment
2. Mattress revetment
   a. Gabion installation
   b. Rock and wire mattress
   c. Rubber-tire mattress
3. Pavement revetment
4. Vertical walls
   a. Seawall
   b. Bulkhead
5. Training structure
   a. Dike
   b. Crib
   c. Fence

GROUP 2: Waterborne Commerce and Recreation Structures

1. Navigational aids
   a. Buoy
   b. Range lights
   c. Warning signs
2. Boathouse
3. Boat launch ramp
4. Boat hoist
5. Dock, wharf, or cargo-handling facility
6. Boat slip
7. Marina facility or mooring facility
8. Pier
9. Piling and piling configuration
10. Stairway
11. Marine railway
12. Ski ramp

(Continued)

Table 1 (Concluded)

GROUP 2: (Continued)

13. Raft
14. Breakwater
15. Hydrologic data-collection platform
16. Submerged obstruction and salvage operations

GROUP 3: Ground Surface Transportation Structures

1. Bridge abutment
2. Bridge support
3. Causeway
4. Walkway
5. Trestle

GROUP 4: Energy Supply and Utility-Related Structures

1. Power plant
2. Oil and gas wells
3. Fossil fuel refinery
4. Utility tower
5. Submerged pipeline
6. Submerged cable crossing
7. Overhead cable crossing

GROUP 5: Discharge and Intake Structures

1. Discharge structure
2. Intake structure

GROUP 6: Other Construction and Engineering Activities

1. Dredging and disposal activities
    a. Open-water disposal
    b. Land disposal
2. Mining
3. Landfill
4. Cofferdam
5. Wetland (artificial)

Table 2

Frequency of Occurrence of Permit Groups

Permit Group*	Coastal Zone** Percent	Interior† Percent
1	9.1	2.6
2	33.3	5.4
3	1.2	5.6
4	1.2	1.8
5	0.9	1.9
6	23.3	13.5

* See Table 1 for types of activities contained in each group.

** Coastal zone extends inland 9 to 12 miles.

† Interior represents all the Mobile District less the coastal zone.

Table 3

Standard Landsat Products Available from the EROS Data Center

SATELLITE DATA

STANDARD LANDSAT			BLACK and WHITE		COLOR	
IMAGE SIZE	NOMINAL SCALE	PRODUCT FORMAT	UNIT * PRICE	PRODUCT CODE	UNIT * PRICE	PRODUCT CODE
55.8mm (2.2 in.)	1 3369000	Film Positive	$8.00	11		
55.8mm (2.2 in.)	1 3369000	Film Negative	10.00	01		
18.5cm (7.3 in.)	1 1000000	Paper	8.00	23	$12.00	63
18.5cm (7.3 in.)	1 1000000	Film Positive	10.00	13	15.00	53
18.5cm (7.3 in.)	1 1000000	Film Negative	10.00	03		
37.1cm (14.6 in.)	1 500000	Paper	12.00	24	25.00	64
74.2cm (29.2 in.)	1 250000	Paper	20.00	26	50.00	66
COLOR COMPOSITE GENERATION					50.00	59

NOTE 1) Portrayed in false color (infrared) and not true color
2) Cost of product from this composite must be added to total cost

COMPUTER COMPATIBLE TAPES (CCT)

TRACKS	b.p.i.	FORMAT	SET PRICE	PRODUCT CODE
7	800	Tape Set	$200.00	82
9	800	Tape Set	200.00	83
9	1600	Tape Set	200.00	84

* Listed prices are current through January 1980.

Table 4

Applications for Which Various MSS Spectral Bands Have Been Found to be the Most Useful

MSS SPECTRAL BAND	4	5	6	7
AIRFIELDS		X		
AIR POLLUTION	X	X		
ATMOSPHERIC SENSITIVITY	X			
BURNED RANGELAND				X
CHLOROPHYLL (LAND)		X		
CHLOROPHYLL (SEA WATER)			X	X
CLOUD PENETRATION				X
CLOUD-SNOW DIFFERENTIATION			X	
CLOUDS (THIN CIRRUS)	X	X		
CROP DIFFERENTIATION				X
DEFOLIATION		X		X
EDDIES		X		X
FLOOD PLAINS				X
FORESTS		X		
GEOLOGIC FEATURES			X	X
GRASS FIRES				X
GROWTH STATE	X			X
HAZE	X			
ICE	X			X
IGNEOUS ROCKS			X	X
IRON (FERRIC)	X	X		
IRRIGATED FIELDS				X
JET CONTRAILS	X	X		
LAKES				X
LAKE EUTROPHICATION	X			
LANDFORM FEATURES		X		
LARGE BRIDGES			X	
LARGE HORIZONTAL CONCRETE STRUCTURES		X		
LITHOLOGY		X		

MSS SPECTRAL BANDS	4	5	6	7
MARSHES			X	
METAMORPHIC ROCK ALLUVIUM DIFFERENTIATION				X
RIVERS			X	X
ROADS	X	X		
SERPENTINE OUTCROP				X
SHALLOW WATER	X			
SHOALS	X			
SHORES			X	X
SMALL LAKES				X
SNOW DETECTION	X			
SNOW LINES (TRANSIENT ON GLACIER)			X	
SNOW LINES (FOREST)	X			
SOIL ASSOCIATIONS		X	X	
SOILS DISCRIMINATION		X		X
SOIL MOISTURE DETECTION		X		
STREAM CHANNELS			X	
STRESS		X		
SURFACE WATER			X	X
TECTONIC FEATURES			X	X
TOPOGRAPHY		X		
TURBIDITY	X	X		
URBAN AREAS	X	X		X
WATER BOUNDARIES			X	X
WATER DEPTH (BATHYMETRY)	X	X		
WATER POLLUTION	X	X		
WATER SEDIMENTATION	X	X		
WETLANDS			X	X
WOODED AREAS	X	X		

Table 5

Variations in Pixel Size Versus Scanner Altitude

Altitude ft	Pixel Size, ft* 0%**	25%	50%	75%	100%
1,000	2.5	2.9	4.0	6.0	8.7
2,000	5.0	5.8	8.1	11.9	17.3
3,000	7.5	8.7	12.1	17.9	26.0
4,000	10.0	11.5	16.2	23.9	34.7
5,000	12.5	14.4	20.2	29.9	43.4
6,000	15.0	17.3	24.3	35.8	52.0
7,000	17.5	20.2	28.3	41.8	60.7
8,000	20.0	23.1	32.4	47.8	69.4
9,000	22.5	26.0	36.4	53.8	78.1
10,000	25.0	28.9	40.4	59.7	86.7
12,000	30.0	34.6	48.5	71.7	104.1
15,000	37.5	43.3	60.7	89.6	130.1
20,000	50.0	57.7	80.9	119.5	173.5
24,000	60.0	69.2	97.1	143.4	208.2

* Length of one side of a square pixel.

** Indicates position of pixel along a scan line. For example, 25% indicates that the sweep of the scanner is at 1/4 of its maximum distance from directly below the aircraft.

Table 6

Cost of Imagery Obtained from the MMS Data

Altitude ft	Cost, Dollars/square mile*	
	Black and White	Color Composites
2,000	96	161
4,000	27	44
7,000	11	17
12,000	5	8
24,000	2	3

* Costs incurred by the WES to produce images from CCT data.

Table 7

Summary of Capabilities of Each Band of the MMS System to Detect Various Features

Description of Feature	Band 1	2	3	4	5	6	7	8	9	10	11
Wooden structures (boat-docks, piers, etc.)	X	X	X	X	X	X	X	X	X	X	
Metal structures (boat-houses, hoists, marinas, etc.)	X	X	X	X	X	X	X	X	X	X	X
Asphalt-paved roads											X
Red clay-covered roads				X	X	X	X	X	X	X	
White silica sand	X	X	X	X	X	X	X	X	X	X	X
Marsh								X	X	X	
Prairie							X	X	X	X	
Forest								X	X	X	
Shoals		X	X	X	X	X	X	X			

Note: X indicates capability to detect individual features.

Table 8

Capability of the MMS to Detect Various Features at Different Altitudes

Feature	Altitude, ft 2,000	4,000	7,000	12,000
Boats	X			
Individual trees	X			
Crop rows	X			
Houses	X	X		
Boathouses	X	X		
Boatdocks	X	X	X	
Piers	X	X	X	
Small water bodies (boat slips, lakes, etc.)	X	X	X	
Large water bodies	X	X	X	X
Roads	X	X	X	X
Prairie-forest interface	X	X	X	X

Note: X denotes a fair-to-good capability for detecting the given feature.

Table 9

Photographic Products Commonly Used in Aerial Photography Remote-Sensing Applications

Prints
Single weight
Double weight
Glossy
Semi-matte
Enlargements
Color
Black-and-White
Dodged
Transparencies
Color
Black-and-White
Negative
Positive
Glass plates (diapositives)
Indexes (indices)
Mosaics
Controlled
Semi-controlled
Uncontrolled

Table 10

Flight Planning Data for 6-in. Focal Length Camera with 9- by 9-in. Format

Flight altitude in feet (above mean terrain)	Scale of photography	Net forward gain per model: Forward lap 56%	Net forward gain per model: Forward lap 60%	Photo width in miles	Photo area in sq miles	Area of net model 20% side lap: Forward lap 56%	Area of net model 20% side lap: Forward lap 60%	Area of net model 30% side lap: Forward lap 56%	Area of net model 30% side lap: Forward lap 60%	Flight line spacing for side lap of: 20%	Flight line spacing for side lap of: 30%
6,000	1:12,000	0.75	0.68	1.70	2.89	1.02	0.93	0.90	0.81	1.36	1.19
8,000	1:16,000	1.00	0.91	2.27	5.15	1.81	1.65	1.59	1.45	1.82	1.59
10,000	1:20,000	1.25	1.14	2.84	8.07	2.84	2.58	2.48	2.26	2.27	1.99
12,000	1:24,000	1.50	1.36	3.41	11.63	4.09	3.72	3.58	3.25	2.73	2.39
14,000	1:28,000	1.75	1.59	3.98	15.84	5.58	5.07	4.74	4.31	3.18	2.78
16,000	1:32,000	2.00	1.82	4.54	20.61	7.25	6.59	6.23	5.67	3.63	3.18
18,000	1:36,000	2.25	2.04	5.11	26.11	9.19	8.35	7.98	7.26	4.09	3.58
20,000	1:40,000	2.50	2.27	5.68	32.26	11.36	10.32	9.98	9.07	4.54	3.98
22,000	1:44,000	2.75	2.50	6.25	39.06	13.75	12.50	12.10	11.00	5.00	4.37
24,000	1:48,000	3.00	2.73	6.82	46.51	16.37	14.88	14.32	13.02	5.46	4.77
26,000	1:52,000	3.25	2.95	7.38	54.46	19.17	17.43	16.86	15.33	5.90	5.17
28,000	1:56,000	3.50	3.18	7.95	63.20	22.25	20.22	19.66	17.87	6.36	5.57
30,000	1:60,000	3.75	3.41	8.52	72.59	25.55	23.23	22.45	20.41	6.82	5.96
32,000	1:64,000	4.00	3.64	9.09	82.63	29.09	26.44	25.65	23.32	7.27	6.36
34,000	1:68,000	4.25	3.86	9.66	93.32	32.85	29.86	28.84	26.22	7.73	6.76
36,000	1:72,000	4.50	4.09	10.22	104.45	36.77	33.42	32.18	29.26	8.18	7.16
38,000	1:76,000	4.75	4.32	10.79	116.42	40.98	37.25	35.98	32.70	8.63	7.55
40,000	1:80,000	5.00	4.54	11.36	129.05	45.43	41.30	39.67	36.06	9.09	7.95

Summary of Available Remote

Agency	Imagery: Type	Imagery: Range of Scales	Coverage: Areas	Coverage: Period and/or Frequency	
Agricultural Stabilization and Conservation Service (ASCS) Aerial Photography Field Office 2511 Parley's Way Salt Lake City, Utah 84109	Panchromatic Color IR	1:10,000 to 1:120,000 Panchromatic Predominant scale is 1:20,000; however, the present trend is to obtain new photography at 1:40,000 scale Color IR Predominant scale is 1:120,000	Panchromatic coverage of approximately 80 percent of the land area of the U. S. including Hawaii. No coverage is available for Alaska. Color IR corn-blight photography coverage of the major corn growing regions of the U. S. (primarily in the midwestern states).	Panchromatic photography coverage period ranges from 1942 to the present. New photography is obtained about every 6 yr, resulting in about 300,000 miles of new photography being flown yearly. Photography acquired by ASCS and its predecessors prior to 1942 has been transferred to the National Archives. Color IR corn-blight photography coverage was obtained during the early 1970's, primarily during the late spring and early summer.	Vario avail at v 9-1 prod and makin Photo was Photo U. are by 6 quire Micro photo avail volve Col prin are
Soil Conservation Service (SCS) Cartographic Division Federal Building Hyattsville, Md. 20782	Panchromatic	1:3,000 to 1:75,000 Predominant scale-1:48,000	All 50 states, District of Columbia, and Puerto Rico. Area of coverage varies considerably from one state to another.	Coverage period ranges from the middle 1940's to the present. No fixed schedule for reflying area coverage. Generally flown as required for updating of soil, timber, and other resource data.	SCS on re Two avail sures and p Photo avail indiv
U. S. Forest Service (USFS) Division of Engineering Washington, D. C. 20250	Panchromatic Black-and-white IR Color Color IR	1:6,000 to 1:80,000 Predominant scale-1:15,840	National Forest areas throughout the U. S.	National forest areas are generally flown on a recurring basis. Frequency of coverages is highly variable among the nine Forest Service regions. Some areas may be flown twice yearly at intervals of several years. Many areas are also flown on an "as-needed" basis in support of special projects. Coverage period ranges from about 1954 to the present.	USFS Photo furn print tive pape Most photo older able

1

Table 11

f Available Remote Sensing Imagery (Aircraft)--Federal Agencies

quency	Availability and Characteristics	Products Available: Type	Format	Size, in.	Cost, ea	Remarks	Procedures for Obtain
hy coverage 2 to the phy is ob- r, result- iles of flown cquired by ora prior ferred to hotography during the y during rly summer.	Various types of prints and other services are available on request. Enlargements can be obtained at various scales on paper ranging in size from 9-1/2 by 9-1/2 in. to 38 by 38 in. Other available products include copy negatives, glass plates, and film positives for light table use and for making diazo or blueprint copies. Photography is available for each of the years it was flown. Photo indexes are available for each county in the U. S. where photography has been flown. The indexes *are usually at a scale of 1 in. to the mile on 20-* by 64-in. paper. One or more indexes may be required to give complete coverage for a county. Microfilm duplicards of <u>all</u> ASCS photo indexes of photography obtained during the period 1942-1974 are available on request. Current U. S. coverage involves about 16,000 cards. Color IR corn-blight photography is available in print or positive transparency format. Enlargements are also available.	Panchromatic	Contact prints	9-1/2 × 9-1/2	$ 2.00	Semimatte finish, double-weight paper	1. Obtain latest ASCS publicati Status Maps" and "Aerial Ph from ASCS, Salt Lake City. Status Maps" shows the late available for each state and Pertinent data shown include coverage, lens focal length. indexes available for each Photography Coverage" is a counties of the various cove 1942) obtained by ASCS and year of photography and numb each county are shown. Als (Order for Aerial Photograph 2. Select photo indexes from th scribed above that will prov of the area of interest. Or If the requester is not sure dexes required, send a map w outlined and ASCS will sele 3. Examine photo indexes and se photographs that will provid of the area of interest. If required, select every other flight line. Fill out ASCS ASCS, Salt Lake City, for se that must be included on ord size desired; quality of eac symbol, roll and exposure nu upper right-hand corner of e and the state and county in located. 4. The color IR corn-blight pho with regular panchromatic co should request specific info cerning indexes, costs, and this imagery.
				12 × 12	4.00		
				17 × 17	5.00		
				24 × 24	6.00		
				38 × 38	12.00		
			Positive transparencies	9-1/2 × 9-1/2	3.00	Polyester base	
				12 × 12	4.50		
				17 × 17	5.50		
				24 × 24	7.50		
				38 × 38	16.00		
		Photo indexes	Contact prints	20 × 24	5.00	Single-weight paper	
			Positive transparencies	20 × 24	6.00	Polyester base	
			Microfilm duplicards	--	1.00 for first card; 0.10 for each additional card	--	
s from the present. refiying ally flown ing of soil, ource data.	SCS photography is available to all Federal agencies on request. Two general types of panchromatic photography are available: controlled mosaics and individual exposures. These types are available at various scales and paper sizes. Photo indexes of various scales and paper sizes are available. These indexes show the flight lines and individual, numbered exposures.	Panchromatic	Contact prints	10 × 10	2.00	All reproductions are printed on double-weight, semimatte paper unless otherwise specified. Approximate scale at which enlargements are desired should be furnished with each order.	1. Request the following public "Status of Aerial Photograph Mosaic Status Maps," and lat publications show SCS photog able for each state, the Dis Puerto Rico. Other informat of photography (only latest scale of photography, camera ber of photo index sheets fo 2. Order pertinent photo index interest (if available). Se graphic exposures from the p 3. SCS does not supply printed cial purchase order along wi sures desired will suffice w
				14 × 14	4.00		
				18 × 18	5.00		
				26 × 26	6.00		
				40 × 40	12.00		
			Controlled mosaics	20 × 24	5.00		
				26 × 26	6.00		
				40 × 40	12.00		
			Photo indexes	20 × 24	5.00		
				40 × 48	15.00		
				20 × 24	5.00		
are gener- ring basis. s is highly ne Forest areas may at inter- . Many on an "se- ort of spe- from about	USFS photography is available on request. Photographic reproductions of USFS holdings can be furnished in a variety of configurations: contact prints, positive transparencies, and glass diapositives. Enlargements to various scales, depending on paper size, can be furnished. Most USFS photography coverage is shown on aerial photography status maps by states. USFS photography older than that shown on the status maps is available for some areas.	Panchromatic and black-and-white IR	Contact prints	5 × 5	2.00	Choice of double-weight semimatte, single-weight glossy, or plastic-coated (waterproof) paper. Stable base (polyester) also available for $1.00 per print extra.	1. Request Technical Report ETR raphy Status Maps," and supp maps of the U. S. from the U Also request photography ord These publications will gene quester with the location, t coverage project number of photography obtained by the cerning the <u>most recently ac</u> be obtained from the USFS re of interest is located. The time" between the acquisitio its inclusion in the publish maps. 2. Examine the aerial photograp mine if appropriate coverage area of interest. *Photo ind* if individual prints are to 3. Photo indexes and photograph from the USFS regional offic involved. The only exceptio is that photography in Regio ordered from the USFS Washin 8 and 9 do not have photogra cilities. However, these re requester with information c coverages of photography in regions.
				7 × 7	2.00		
				9 × 9	2.00		
				14 × 14	4.00		
				18 × 18	5.00		
				27 × 27	6.00		
				36 × 36	12.00		
			Positive transparencies	70 mm	2.00		
				5 × 5	3.00		
				9 × 9	3.00		
			Glass diapositives	0.060, 0.130, and 0.250 thick	10.00		
			Photo indexes	10 × 12	3.00	Double-weight, semimatte paper	
				20 × 24	5.00		
		Color and Color IR	Contact prints	5 × 5	7.00		
				9 × 9	7.00		
				14 × 14	12.00		
				18 × 18	15.00		
				27 × 27	20.00		
				36 × 36	30.00		
			Positive transparencies	70 mm	5.00		
				5 × 5	6.00		
				9 × 9	12.00		

(Continued)

l Agencies

ice	Type	Format	Size, in. (Products Available)	Cost, ea	Remarks	Procedures for Obtaining Imagery
ces are be obtained ize from er available plates, and for	Panchromatic	Contact prints	9-1/2 × 9-1/2 12 × 12 17 × 17 24 × 24 38 × 38	$ 2.00 4.00 5.00 6.00 12.00	Semimatte finish, double-weight paper	1. Obtain latest ASCS publications "Aerial Photography Status Maps" and "Aerial Photography Coverage" from ASCS, Salt Lake City. The "Aerial Photography Status Maps" shows the latest photographic coverage available for each state and county of the U. S. Pertinent data shown include: year and scale of coverage, lens focal length, and number of photo indexes available for each county. The "Aerial Photography Coverage" is a listing by states and counties of the various coverages (dating back to 1942) obtained by ASCS and its predecessors. The year of photography and number of photo indexes for each county are shown. Also request ASCS Form 441 (Order for Aerial Photographs).
e years it unty in the		Positive transparencies	9-1/2 × 9-1/2 12 × 12 17 × 17 24 × 24 38 × 38	3.00 4.50 5.50 7.50 16.00	Polyester base	
The indexes mile on 20- av be re-	Photo indexes	Contact prints	20 × 24	5.00	Single-weight paper	
		Positive transparencies	20 × 24	6.00	Polyester base	
county. indexes of 1942-1974 are verage in- ilable in Enlargements		Microfilm duplicards	--	1.00 for first card; 0.10 for each additional card	--	2. Select photo indexes from the ASCS publications described above that will provide the desired coverage of the area of interest. Order selected indexes. If the requester is not sure of the number of indexes required, send a map with the area of interest outlined and ASCS will select the indexes required. 3. Examine photo indexes and select the individual photographs that will provide the desired coverage of the area of interest. If stereo coverage is not required, *select every other photograph along each* flight line. Fill out ASCS Form 441 and send to ASCS, Salt Lake City, for servicing. Pertinent data that must be included on order form include paper size desired; quality of each print; code or symbol, roll and exposure numbers (usually found in upper right-hand corner of each photograph on index); *and the state and county in which the coverage is* located. 4. The color IR corn-blight photography is not indexed with regular panchromatic coverage. Requester should request specific information from ASCS concerning indexes, costs, and procedures for obtaining this imagery.
eral agencies graphy are vidual expo- rious scales	Panchromatic	Contact prints	10 × 10 14 × 14 18 × 18 26 × 26 40 × 40	2.00 4.00 5.00 6.00 12.00	All reproductions are printed on double-weight, semimatte paper unless otherwise specified. Approximate scale at which enlargements are desired should be furnished with each order.	1. Request the following publications from SCS: "Status of Aerial Photography," "Aerial Photography Mosaic Status Maps," and latest cost list. These publications show SCS photographic coverages available for each state, the District of Columbia, and Puerto Rico. Other information shown includes year of photography (only latest photography shown), scale of photography, camera focal length, and number of photo index sheets for complete coverage.
er sizes are ht lines and		Controlled mosaics	20 × 24 26 × 26 40 × 40	5.00 6.00 12.00		
		Photo indexes	20 × 24 40 × 48 20 × 24	5.00 15.00 5.00		2. Order pertinent photo index sheets for area of interest (if available). Select individual photographic exposures from the photo indexes. 3. SCS does not supply printed order forms. An official purchase order along with a list of the exposures desired will suffice when ordering from SCS.
g. inge can be s: contact ass diaposi- depending on	Panchromatic and black-and-white IR	Contact prints	5 × 5 7 × 7 9 × 9 14 × 14 18 × 18 27 × 27 36 × 36	2.00 2.00 2.00 4.00 5.00 6.00 12.00	Choice of double-weight semimatte, single-weight glossy, or plastic-coated (waterproof) paper. Stable *base (polyester) also available for* $1.00 per print extra.	1. Request Technical Report ETR-7100-4a, "Aerial Photography Status Maps," and supplemental photo status maps of the U. S. from the USFS Washington Office. *Also request photography order form and price list.* These publications will generally provide the requester with the location, type, scale, date, and coverage project number of all but the very latest photography obtained by the USFS. Information concerning the <u>most recently acquired</u> photography can be obtained from the USFS region in which the area *of interest is located. There is normally a "lag* time" between the acquisition of photography and its inclusion in the published photography status maps.
on aerial S photography s is avail-		Positive transparencies	70 mm 5 × 5 9 × 9	2.00 3.00 3.00		
		Glass diapositives	0.060, 0.130, and 0.250 thick	10.00		
		Photo indexes	10 × 12 20 × 24	3.00 5.00	Double-weight, semimatte paper	2. Examine the aerial photography status maps to determine if appropriate coverage is available for the area of interest. Photo indexes should be ordered if individual prints are to be selected.
	Color and Color IR	Contact prints	5 × 5 9 × 9 14 × 14 18 × 18 27 × 27 36 × 36	7.00 7.00 12.00 15.00 20.00 30.00		3. Photo indexes and photography should be ordered from the USFS regional office serving the area involved. The only exception to this procedure is that photography in Regions <u>8</u> and <u>9</u> should be ordered from the USFS Washington office. Regions 8 and 9 do not have photographic reproduction facilities. However, these regions can provide the requester with information concerning the types and coverages of photography in their respective regions.
		Positive transparencies	70 mm 5 × 5 9 × 9	5.00 6.00 12.00		

Tal

Agency	Imagery: Type	Imagery: Range of Scales	Imagery: Coverage: Areas	Imagery: Coverage: Period and/or Frequency	
U. S. Geological Survey (USGS)* Mid-Continent Mapping Center Map and Field Data Section Box 133 (or 900 Pine Street) Rolla, Mo. 65401	Panchromatic	1:11,000 to 1:80,000	Coverage area consists of the following 14 states: Arkansas, Illinois, Iowa, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Oklahoma, Nebraska, North Dakota, South Dakota, and Wisconsin.	Coverage period ranges from 1943 to the present. Frequency of coverage depends largely on the mapping requirements of the USGS. Areas where substantial changes in physical and cultural features are most prevalent generally are flown periodically.	USGS Phot photo geol obli from Prin with rati Phot photo
U. S. Geological Survey (USGS)* Eastern Mapping Center Map and Field Data Center 536 National Center Reston, Va. 22092	Panchromatic	1:12,000 to 1:56,000 Predominant scale is 1:24,000	Coverage area consists of the following 22 states: Alabama, Georgia, Florida, North Carolina, South Carolina, Tennessee, Kentucky, Indiana, Ohio, West Virginia, Virginia, Maryland, Delaware, Pennsylvania, New York, New Jersey, Rhode Island, Connecticut, Massachusetts, New Hampshire, Vermont, and Maine. Coverage is also provided for the District of Columbia, Puerto Rico, and the Virgin Islands.	Coverage period ranges from 1939 to the present. Frequency of coverage depends largely on the mapping requirements of the USGS. Areas where substantial changes in physical and cultural features are most prevalent generally are flown periodically.	
U. S. Geological Survey (USGS) Earth Resources Observation Systems *(EROS) Data Center* 10th and Dakota Avenues Sioux Falls, S. Dak. 57198 EROS Applications Assistance Facility** National Space Technology Laboratories Bay St. Louis, Miss. 39520	USGS mapping photography and NASA high- and low-altitude photography. Specific types are: *panchromatic, color, and color IR*	<u>USGS photography</u> 1:12,000 to 1:90,000 Predominant *scale is 1:24,000* <u>NASA photography</u> 1:30,000 to 1:120,000	USGS photography: discontinuous areas throughout the conterminous U. S., Alaska, Hawaii, and territories. NASA photography: test sites within the conterminous U. S. These test sites vary widely in areal extent and location. A small amount of coverage is available for a number of foreign countries, primarily countries in Central and South America.	Coverage period for photography ranges from 1942 to the present. The photography was usually obtained during the late fall or early spring. Map updating requirements have resulted in multiple coverages of many areas and various dates. Coverage period for NASA photography ranges from 1965 to the present. Photography is being flown annually at selected test sites throughout the U. S.	All able *Panc* aeria the in 9 oblic verti tion, varic land and held All enlai in r 1941 D. C Colo Cent Reso alti NASA the image large whit Prov on a loca alti agen of a Cent Beca phot phot are 8 by able Copi phot purc prep area Upda

* This office also provides information and order imagery held by the EROS Data Center, Sioux Falls, S. Dak. Types and costs of imagery are the same as described for the EROS Data Center.
** These facilities act as regional support centers to the EROS Data Center in Sioux Falls, S. Dak. Both have computer terminals connecting them to the EROS Data Center. These centers provide assistance in obt

Table 11 (Continued)

uency	Availability and Characteristics	Products Available: Type	Format	Size, in.	Cost, ea	Remarks	Procedures for Obtaini
from 1943 epends require- as where physical re most flown	USGS photography is available on request. Photography generally consists of vertical aerial photography obtained primarily for topographic and geologic mapping. Some of the photography is low oblique photographs taken with cameras tilted 20 deg from the vertical. Prints are available with stereoscopic overlap or without such overlap. Enlargements to an exact ratio or to a specific scale are available. Photo indexes are available for nearly all USGS photography within the coverage area.	Panchromatic	Contact prints	9 × 9 18 × 18 27 × 27 36 × 36	\$ 2.00 5.00 6.00 12.00		1. Request the state index map(s photography that is applicabl interest. These indexes will concerning the area of covera symbol, and the date and scal Only the latest photographic of status date shown on margi 2. Locate the area of interest o procedure will indicate the a scale, and project symbol of specific area. 3. If the size of the area of in requester should ask for phot line diagrams of the area. I then be selected from these i ing photo indexes, include th area of interest or an outlin able map. Include project sy map indexes, when possible. 4. In some instances, photograph status date of the state inde The USGS Mapping Center staff tion concerning any new photo the state index map.
			Film positives	9 × 9	3.00		
			Film negatives	9 × 9	6.00		
		Photo indexes	Contact prints	10 × 12 20 × 24	3.00 5.00		
		Kelsh plates	Contact glass	0.130 thickness	10.00		
		ER-55 plates	Reductions on glass	11 × 11 cm, 0.090 thick	10.00		
		Transformed prints	Contact prints	--	7.00		
from 1939 epends require- as where physical re most flown	Same as above	Same as above	Same as above	Same as above	Same as above		Same as abov
ography present. ally ob- fall or ing re- l in ny areas photog- o the being ed test S.	All imagery held by the EROS Data Center is available for sale on request. Panchromatic coverage is composed primarily of aerial mapping photography taken by USGS. Most of the photography is comprised of vertical photographs in 9- by 9-in. format. The remainder are either low oblique, taken with cameras tilted 20 deg from the vertical, or high-altitude photographs. In addition, panchromatic photography flown in support of various projects of the Bureau of Reclamation and land management is provided to the USGS for indexing and distribution. A computerized index to the USGS-held photographs is maintained at the Data Center. All photographs are available at contact scales, enlargements, or reductions, on film or on paper, in rolls or cut. Photographs obtained prior to 1941 are held by the National Archives, Washington, D. C. Color and color IR imagery held at the EROS Data Center was acquired as a result of the NASA Earth Resources Aircraft Program. Low-altitude and high-altitude coverage is available. Black-and-white NASA aircraft imagery is also available. Copies of the NASA black-and-white, color, and color IR imageries can be purchased at contact scales, enlargements, or reductions, in color or black and white, on film or on paper, in rolls, or cut. Provided with each image order are annotations on a computer printout that provide data, local time, geographic coordinates, print scale, altitude, film type, sensor type, originating agency, project, roll, and frame. A catalog of all NASA imagery is maintained at the Data Center. Because of the large number of panchromatic photographs available, they have been combined into photo indexes. The majority of the photo indexes are 7-1/2-min quadrangles that cover approximately 8 by 10 miles. Over 50,000 photo indexes are available at the Data Center. Copies of the NASA aircraft imagery and the USGS photography produced on 16-mm film are available for purchase. These films are designed to provide prepurchase evaluation of such parameters as: areal coverage, cloud cover, and sensor angle. Updating of these browse films is irregular.	Aerial mapping photography Panchromatic	Film positives	9 × 9	3.00	Roll-to-roll reproductions delivered in roll carries a 50 percent reduction in price.	1. Obtain Geographic Computer Se the EROS Data Center or from facilities. Fill out form an Center for processing. Based contained on the form, the Da search for the appropriate ma what is available for the req est meeting the requester's a computer will provide a print which a final selection can b tion in the computer printout locate the browse film of the for cloud coverage and geogra placing an order. 2. After the computer search ove is completed, the Data Center quester the computer printout sheet and order forms, from w selected and ordered. 3. Imagery can also be obtained ing the Data Center or either facilities. However, the req to provide sufficient informa geographic area of interest, used for, and the manner in w used.
			Film negatives	9 × 9	6.00		
			Paper	9 × 9 18 × 18 27 × 27 36 × 36	2.00 5.00 6.00 12.00		
		NASA aircraft photography Panchromatic	Film positives	2.2 × 2.2 4.5 × 4.5 9 × 9 9 × 18	2.00 2.00 3.00 6.00		
			Film negatives	2.2 × 2.2 4.5 × 4.5 9 × 9 9 × 18	4.00 4.00 6.00 12.00		
			Paper	4.5 × 4.5 9 × 9 9 × 18 18 × 18 27 × 27 36 × 36	2.00 2.00 4.00 5.00 6.00 12.00		
		NASA aircraft photography Color, color IR	Film positives	2.2 × 2.2 4.5 × 4.5 9 × 9 9 × 18	5.00 6.00 12.00 24.00		
			Paper	4.5 × 4.5 9 × 9 9 × 18 18 × 18 27 × 27 36 × 36	6.00 7.00 14.00 15.00 20.00 30.00		
		Browse film (black and white)	Microfilm	16mm--100 ft 35mm--100 ft	15.00 20.00		
		Browse film (color)	Microfilm	16mm--100 ft 35mm--100 ft	35.00 40.00		
		Kelsh plates (black and white)	Glass contact prints	9 × 9	10.00		
		Transformed prints--from convergent or transverse low oblique photographs (black and white)	--	--	7.00		
		Photo indexes (black and white)	Size A	10 × 12	3.00		
			Size B	20 × 24	5.00		

(Continued)

sistance in obtaining imagery products held at the EROS Data Center, and furnish guidance for using remotely sensed data.

Characteristics	Products Available: Type	Format	Size, in.	Cost, ea	Remarks	Procedures for Obtaining Imagery
e on request. ts of vertical aerial ly for topographic and he photography is low th cameras tilted 20 deg ereoscopic overlap or gements to an exact are available. for nearly all USGS age area.	Panchromatic	Contact prints	9 × 9	$ 2.00		1. Request the state index map(s) of available USGS photography that is applicable to the area of interest. These indexes will provide information concerning the area of coverage available, project symbol, and the date and scale of the photography. Only the latest photographic coverage is shown (as of status date shown on margin of index). 2. Locate the area of interest on the index map. This procedure will indicate the availability, date, scale, and project symbol of photography for the specific area. 3. If the size of the area of interest is large, the requester should ask for photo indexes or flight line diagrams of the area. Individual prints can then be selected from these indexes. When requesting photo indexes, include the coordinates of the area of interest or an outline of the area on a suitable map. Include project symbol shown on the state map indexes, when possible. 4. In some instances, photography postdating the status date of the state index may be available. The USGS Mapping Center staff can furnish information concerning any new photography not included on the state index map.
			18 × 18	5.00		
			27 × 27	6.00		
			36 × 36	12.00		
		Film positives	9 × 9	3.00		
		Film negatives	9 × 9	6.00		
	Photo indexes	Contact prints	10 × 12	3.00		
			20 × 24	5.00		
	Kelsh plates	Contact glass	0.130 thickness	10.00		
	ER-55 plates	Reductions on glass	11 × 11 cm, 0.090 thick	10.00		
	Transformed prints	Contact prints	--	7.00		
above	Same as above	Same as above	Same as above	Same as above		Same as above
Data Center is avail- posed primarily of aken by USGS. Most of of vertical photographs remainder are either low tilted 20 deg from the hotographs. In addi- hy flown in support of au of Reclamation and to the USGS for indexing rized index to the USGS- ed at the Data Center. at contact scales, on film or on paper, obtained prior to Archives, Washington, ld at the EROS Data ult of the NASA Earth Low-altitude and high- le. Black-and-white available. Copies of lor, and color IR contact scales, en- color or black and in rolls, or cut. r are annotations rovide data, inates, print scale, type, originating rame. A catalog ined at the Data of panchromatic have been combined into of the photo indexes t cover approximately photo indexes are avail- imagery and the USGS film are available for signed to provide h parameters as: and sensor angle. is irregular.	Aerial mapping photography Panchromatic	Film positives	9 × 9	3.00	Roll-to-roll reproductions delivered in roll carries a 50 percent reduction in price.	1. Obtain Geographic Computer Search inquiry form from the EROS Data Center or from the regional EROS facilities. Fill out form and send to EROS Data Center for processing. Based on the information contained on the form, the Data Center computer will search for the appropriate materials, indicating what is available for the requester's area of interest meeting the requester's specifications. The computer will provide a printout of references from which a final selection can be made. From information in the computer printout, it is possible to locate the browse film of the imagery to check it for cloud coverage and geographic coverage before placing an order. 2. After the computer search over the area of interest is completed, the Data Center will send the requester the computer printout along with a decoding sheet and order forms, from which imagery can be selected and ordered. 3. Imagery can also be obtained by telephoning or visiting the Data Center or either of the regional EROS facilities. However, the requester must be prepared to provide sufficient information concerning the geographic area of interest, what the data will be used for, and the manner in which the data will be used.
		Film negatives	9 × 9	6.00		
		Paper	9 × 9	2.00		
			18 × 18	5.00		
			27 × 27	6.00		
			36 × 36	12.00		
	NASA aircraft photography Panchromatic	Film positives	2.2 × 2.2	2.00		
			4.5 × 4.5	2.00		
			9 × 9	3.00		
			9 × 18	6.00		
		Film negatives	2.2 × 2.2	4.00		
			4.5 × 4.5	4.00		
			9 × 9	6.00		
			9 × 18	12.00		
		Paper	4.5 × 4.5	2.00		
			9 × 9	2.00		
			9 × 18	4.00		
			18 × 18	5.00		
			27 × 27	6.00		
			36 × 36	12.00		
	NASA aircraft photography Color, color IR	Film positives	2.2 × 2.2	5.00		
			4.5 × 4.5	6.00		
			9 × 9	12.00		
			9 × 18	24.00		
		Paper	4.5 × 4.5	6.00		
			9 × 9	7.00		
			9 × 18	14.00		
			18 × 18	15.00		
			27 × 27	20.00		
			36 × 36	30.00		
	Browse film (black and white)	Microfilm	16mm--100 ft	15.00		
			35mm--100 ft	20.00		
	Browse film (color)	Microfilm	16mm--100 ft	35.00		
			35mm--100 ft	40.00		
	Kelsh plates (black and white)	Glass contact prints	9 × 9	10.00		
	Transformed prints--from convergent or transverse low oblique photographs (black and white)	--	--	7.00		
	Photo indexes (black and white)	Size A	10 × 12	3.00		
		Size B	20 × 24	5.00		

ld at the EROS Data Center, and furnish guidance for using remotely sensed data.

(Sheet 2 of 3)

Agency	Imagery			
	Type	Range of Scales	Coverage	
			Areas	Period and/or Frequency
National Ocean Survey (NOS) Coastal Mapping Division, C-3415 Rockville, Md. 20852	Panchromatic Black-and-white IR Color Color IR	1:5,000 to 1:60,000	Coastal areas and most civil airports of the U. S., including Alaska, Hawaii, Puerto Rico, and Virgin Islands.	Imagery held by NOS ranges from 1943 to the present time, but varys from one area to another. No fixed schedule for reflying o areas exists. Areas are flown based on the requirements for th updating of aeronautical and nautical charts, e.g. after majo shoreline changes due to storms, etc.
National Archives and Records Service Cartographic Archives Division Washington, D. C. 20408	Panchromatic	1:15,840 to 1:56,600	Approximately 85 percent of the contiguous land in the U. S.	The period of coverage ranges from 1934 to 1947. The majority of the photography, however, was flown during the period 1935 to 1942.
Tennessee Valley Authority (TVA) Maps and Surveys Branch Chattanooga, Tenn. 37401	Panchromatic Black-and-white IR Color Color IR Thermal IR	1:400 to 1:30,000	Complete coverage of the Tennessee Valley drainage basin (includes portions of Tennessee, Georgia, Kentucky, Alabama, North Carolina, Virginia, and Mississippi) by panchromatic photography. Selected areas and/or sites within the Tennessee River watershed by color, color IR, black-and-white IR, and thermal IR. High-altitude coverage over about 60 percent of Tennessee River drainage basin by color and color IR.	Panchromatic photography coverag period ranges from 1925 to present. Color, color IR, and black-and-white IR photography coverage period ranges from the 1960's to present. No fixed schedule for acquisitio of imagery exists. Areas are flown on an "as-needed" basis in support of special projects or programs.

Table 11 (Concluded)

		Products Available					
equency	Availability and Characteristics	Type	Format	Size, in.	Cost, ea	Remarks	Procedures for Obt
anges from ime, but o another. reflying of are flown ents for the cal and after major to storms,	NOS imagery is single lens, special purpose imagery. Usually consists of single strip or a few parallel strips of photographs. Reproductions of all imagery available on request.	Panchromatic and black-and-white IR	Contact prints	9 × 9 18 × 18 27 × 27 36 × 36	$ 2.00 5.00 6.00 12.00	Printed on double-weight glossy paper unless double-weight matte is specified	1. No photo mosaic-type inde are maintained. Photogra on 1:250,000-scale base m 1 deg of latitude by 1 de exposure indicated by a d scale bases are used for are maintained for each t prints of indexes are ava
			Film positives	9 × 9	3.00	Individually contact printed from aerial negative	
			Copy negatives	9 × 9	6.00	Individually printed on film	
			Contact diapositives	9 × 9	10.00	On glass, for 1st and 2nd order plotting instruments	2. Potential users should de of interest by geographic description, or a sketch. area of interest should b coverage desired should b
		Color and color IR	Contact prints	9 × 9 18 × 18 27 × 27 36 × 36	7.00 15.00 20.00 30.00	Glossy finish	3. For positive identificati should specify the year, serial number. This info from the photo index.
			Transparencies	9 × 9 18 × 18 27 × 27 36 × 36	7.00 15.00 20.00 30.00		4. Authorization to purchase areas must be obtained by military authorities.
		Ozalid prints of photo indexes for each type of imagery coverage	1:250,000 scale or larger	—	0.50	Costs shown are as of July 1974.	
e ranges he majority owever, was od 1935 to	Reproductions of all photography held by the National Archives is available on request. Reproduction is in form of contact prints in a standard size of 10 by 10 in. Enlargements can be furnished at various scales, depending on paper size requested.	Panchromatic	Contact prints	10 × 10 14 × 14 18 × 18 27 × 28 40 × 41	2.00 4.00 5.00 6.00 12.00	Federal agencies receive a 10 percent discount on their orders.	1. Request Special List Numb in the National Archives. Part I is an alphabetical then by county, of the ae available. Date and sour shown. Number of photo i indicated. Part II consi showing the name or symbo more than one county, the of indexes, and scale of
		Photo indexes	Contact mosaics	--	5.00	Costs shown are as of April 1975.	2. Select and order photo in Special List. Individual from the photo indexes. order index sheets, the u Archives with a map, sket precise area of interest. then select the photograp quested area and furnish reproduction.
phy coverage 25 to black-and- coverage e 1960's to acquisition reas are d" basis in ojects or	Reproductions of all panchromatic photography at a scale of 1 in. = 2000 ft are available on request. Reproduction of this coverage is normally in 9- by 9-in. contact print format. Enlargements can be furnished at various scales, depending on paper size requested. The high-altitude color and color IR photography is in 9- by 9-in. transparency format. Reproductions in form of black-and-white negatives and/or contact prints can be obtained. The color, color IR, black-and-white IR, and thermal IR required by Maps and Surveys Branch equipment is on 70-mm and 9- by 9-in. film format. Reproductions of the color IR and black-and-white IR can be furnished. Reproductions of color and thermal IR are generally not furnished, but are available for inspection at the Maps and Survey Branch. A few panchromatic photo mosaics of selected areas are available at scales of 1 in. = 2000 ft and 1 in. = 4000 ft. They vary in quality and format.	Panchromatic	Contact prints	7 × 7 or 9 × 9 21 × 21 or smaller 27 × 28 or smaller 32 × 40 or smaller 40 × 40 or smaller	2.00 5.00 6.88 11.25 13.75	Glossy or semimatte finish	1. All photography held by T minute quadrangle map cov Valley area. Photographi minute form, are availabl raphy in photocopy and/or In many areas, the basic with the *special purpose* scales and dates.
			Photo mosaics	--	1.50/ft^2 of paper used	Glossy or semimatte finish	2. Requests for photography est, scale desired, size stereo or conventional co (glossy or semimatte), an then advise what photogra scale, dates, and other p
		Color, color IR, black-and-white IR	No firm cost information available; formats and costs for these imagery types are highly variable; requester should contact TVA for specific needs and price quotations.				
		Photo indexes	Photocopy Blue line	7-1/2 minute 7-1/2 minute	3.75 1.25		3. If area of interest can b TVA and/or USGS quad cove area, the photo indexes c be ordered. The requeste individual exposures requ

	Products Available					
etics	Type	Format	Size, in.	Cost, ea	Remarks	Procedures for Obtaining Imagery
urpose imagery. few parallel of all imagery	Panchromatic and black-and-white IR	Contact prints	9 × 9 18 × 18 27 × 27 36 × 36	$ 2.00 5.00 6.00 12.00	Printed on double-weight glossy paper unless double-weight matte is specified	1. No photo mosaic-type indexes of available imagery are maintained. Photographs are normally indexed on 1:250,000-scale base maps that cover an area of 1 deg of latitude by 1 deg of longitude with each exposure indicated by a dot. Occasionally, larger scale bases are used for indexes. Separate indexes are maintained for each type of imagery. Ozalid prints of indexes are available on request. 2. Potential users should describe the specific area of interest by geographic coordinates, a detailed description, or a sketch. Photo indexes of the area of interest should be requested. Photographic coverage desired should be selected from indexes. 3. For positive identification, each photograph ordered should specify the year, camera designation, and serial number. This information can be obtained from the photo index. 4. Authorization to purchase photographs of classified areas must be obtained by the user from appropriate military authorities.
		Film positives	9 × 9	3.00	Individually contact printed from aerial negative	
		Copy negatives	9 × 9	6.00	Individually printed on film	
		Contact diapositives	9 × 9	10.00	On glass, for 1st and 2nd order plotting instruments	
	Color and color IR	Contact prints	9 × 9 18 × 18 27 × 27 36 × 36	7.00 15.00 20.00 30.00	Glossy finish	
		Transparencies	9 × 9 18 × 18 27 × 27 36 × 36	7.00 15.00 20.00 30.00		
	Ozalid prints of photo indexes for each type of imagery coverage	1:250,000 scale or larger	—	0.50	Costs shown are as of July 1974.	
by the Na- st. Reproduc- e standard size furnished at ze requested.	Panchromatic	Contact prints	10 × 10 14 × 14 18 × 18 27 × 28 40 × 41	2.00 4.00 5.00 6.00 12.00	Federal agencies receive a 10 percent discount on their orders.	1. Request Special List Number 25, Aerial Photographs in the National Archives. The list has two parts. Part I is an alphabetical arrangement by state, then by county, of the aerial photographic coverage available. Date and source of photography is also shown. Number of photo indexes for each county is indicated. Part II consists of numbered entries showing the name or symbol of each survey covering more than one county, the counties covered, number of indexes, and scale of photography. 2. Select and order photo indexes as indicated in the Special List. Individual prints can then be ordered from the photo indexes. If user does not wish to order index sheets, the user can furnish the Archives with a map, sketch, or description of the precise area of interest. Archives personnel will then select the photographic coverage for the requested area and furnish a quote for cost or reproduction.
	Photo indexes	Contact mosaics	--	5.00	Costs shown are as of April 1975.	
ography at a on request. lly in 9- by nts can be on paper hotography is eproductions nd/or contact	Panchromatic	Contact prints	7 × 7 or 9 × 9 21 × 21 or smaller 27 × 28 or smaller 32 × 40 or smaller 40 × 40 or smaller	2.00 5.00 6.88 11.25 13.75	Glossy or semimatte finish	1. All photography held by TVA is keyed to 7-1/2-minute quadrangle map coverage of the Tennessee Valley area. Photographic indexes, in 7-1/2-minute form, are available for the basic photography in photocopy and/or ozalid blue-line prints. In many areas, the basic coverage is supplemented with the special purpose photography of various scales and dates. 2. Requests for photography should define area of interest, scale desired, size (if enlargements desired), stereo or conventional coverage, type of finish (glossy or semimatte), and intended use. TVA will then advise what photography is available, giving scale, dates, and other pertinent data. 3. If area of interest can be located on 7-1/2-minute TVA and/or USGS quad coverage of the Tennessee Valley area, the photo indexes covering the subject area may be ordered. The requester can then select the individual exposures required.
		Photo mosaics	--	$1.50/ft^2$ of paper used	Glossy or semimatte finish	
R, and thermal equipment is Reproductions can be fur- ermal IR are able for in- . lected areas 0 ft and and format.	Color, color IR, black-and-white IR	No firm cost information available; formats and costs for these imagery types are highly variable; requester should contact TVA for specific needs and price quotations.				
	Photo indexes	Photocopy Blue line	7-1/2 minute 7-1/2 minute	3.75 1.25		

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Table 12

Corps of Engineers Sources of Imagery

Agency or Organization: Division	Agency or Organization: District	Imagery: Type	Imagery: Range of Scales	Coverage: Area	Coverage: Period	Coverage: Frequency	Availability an
U. S. ARMY ENGR DIV, LOWER MISS. VALLEY Mail Address: P. O. Box 80 Vicksburg, Miss. 39180	U. S. Army Engr. Dist, NEW ORLEANS Mail Address: P. O. Box 60267 New Orleans, La. 70160	Panchromatic Color Color IR	1:2,000-1:48,000 Predominant-- 1:10,000-1:20,000	Mississippi River, Mississippi Delta, Red River, Calcasieu River, Intracoastal Waterway, Lake Pontchartrain perimeter, Mississippi River Outlet, Atchafalaya Basin, coastal Louisiana	1930-1975	As required	Photography norm Government age of contact pr from 7-9 by 1 duction facil limited to par About 98% of c graphic maps a consists of ph
U. S. ARMY ENGR DIV, SOUTH ATLANTIC 510 Title Bldg. 30 Pryor St., S.W. Atlanta, Ga. 30303	U. S. Army Engr Dist, MOBILE Mail Address: P. O. Box 2288 Mobile, Ala. 36628	Panchromatic Color Color IR Black-and-white IR	1:2,400-1:30,000	Military installations, navigable waterways, some beach and coastal areas (Fla., Ala., Miss.), major harbors	Early 1940's-1975	As required	Photography avai agencies; cons 3-in. and 9- b Reproduction f office limited raphy. Photo coverage.
U. S. ARMY COASTAL ENGR RESEARCH CENTER (CERC) Kingman Building Ft. Belvoir, Va. 22060		Panchromatic Black-and-white IR Color Color IR	1:1,200-1:24,000	Coastal areas of the U. S.	1940's--1975	As required	Photography avail agencies; incl 18-in. contact parencies. Rep Center limited format. Covera aperture cards hensive data ba imagery establi is being done c division or dis
U. S. ARMY ENGR TOPOGRAPHIC LABORATORIES (ETL) RESEARCH INSTITUTE CENTER FOR REMOTE SENSING Ft. Belvoir, Va. 22060		Panchromatic Color Color IR Thermal IR	1:5,000-1:100,000 Predominant--1:20,000	Primarily Alaska, Canada, domestic United States, Southeast Asia, and Panama (in order of most extensive coverage). Thermal IR coverage generally limited to Arctic and sub-Arctic areas, with some tropical and desert coverage.	1937-1975	Some areas characterized by six different periods of coverage	Photography avail agencies; consi 9-in. contact p transparencies. duction facilit reproduction of ping Agency. P available for c is experimental portion of the readily availab

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Table 12

Corps of Engineers Sources of Imagery

Imagery						
		Coverage				
Type	Range of Scales	Area	Period	Frequency	Availability and Characteristics of Imagery	Procedures for Obtaining Imagery
Panchromatic Color Color IR	1:2,000-1:48,000 Predominant-- 1:10,000-1:20,000	Mississippi River, Mississippi Delta, Red River, Calcasieu River, Intracoastal Waterway, Lake Pontchartrain perimeter, Mississippi River Outlet, Atchafalaya Basin, coastal Louisiana	1930-1975	As required	Photography normally available to other Government agencies; consists primarily of contact prints and mosaics ranging from 7-9 by 15 in. to 15 by 15 in. Reproduction facilities at district office limited to panchromatic photography. About 98% of coverage indexed on topographic maps at various scales, remainder consists of photo indexes.	Chief, Drafting Branch, Engineering Div, New Orleans District
Panchromatic Color Color IR Black-and-white IR	1:2,400-1:30,000	Military installations, navigable waterways, some beach and coastal areas (Fla., Ala., Miss.), major harbors	Early 1940's-1975	As required	Photography available to other Government agencies; consists primarily of 3- by 3-in. and 9- by 9-in. contact prints. Reproduction facilities at district office limited to panchromatic photography. Photo indexes available for coverage.	Chief, Survey Section, Mobile District
Panchromatic Black-and-white IR Color Color IR	1:1,200-1:24,000	Coastal areas of the U. S.	1940's--1975	As required	Photography available to other Government agencies; includes 9- by 9-in. and 9- by 18-in. contact prints and positive transparencies. Reproduction facilities at Center limited to copying at true-scale format. Coverage is indexed on 35-mm aperture cards and is part of a comprehensive data bank of U. S. coastal imagery established by CERC. Indexing is being done on a Corps of Engineers division or district basis.	Chief, Engineering Development Div, CERC
Panchromatic Color Color IR Thermal IR	1:5,000-1:100,000 Predominant--1:20,000	Primarily Alaska, Canada, domestic United States, Southeast Asia, and Panama (in order of most extensive coverage). Thermal IR coverage generally limited to Arctic and sub-Arctic areas, with some tropical and desert coverage.	1937-1975	Some areas characterized by six different periods of coverage	Photography available to other Government agencies; consists primarily of 9- by 9-in. contact prints and some positive transparencies. Center has no reproduction facilities, but can arrange for reproduction of imagery at Defense Mapping Agency. Photo and map indexes available for coverage. Part of coverage is experimental imagery in near or visual portion of the spectrum and may not be readily available to other agencies.	Chief, Center for Remote Sensing, ETL

Table 13

State Agency Sources of Imagery

State	Agency or Organization	Imagery: Type	Format	Range of Scales	Flown By	Coverage: Area	Period	Frequency	Indexing
Alabama	Alabama Highway Dept. 11 South Union St. Montgomery, Ala. 36104	Black and white	9- by 9-in. contact prints	1:4,800-1:40,000 Predominant--1:20,000	USDA, and commercial firms	County-wide coverage of the state. Additional coverages along certain roadway corridors	1952-1975	As required	Photo inde[illegible] county [illegible]
	Alabama State Dept. of Revenue Ad Valorem Tax Div. 1021 Madison Ave. Montgomery, Ala. 36111	Black and white	9- by 9-in. negatives and contact prints	1:3,600-1:24,000	Commercial firms	Full coverage of all counties in state	1972-1975	As required for tax map revisions. Generally flown during leaf-off season	Photo inde[illegible]
	Geological Survey of Alabama P. O. Drawer 0 University, Ala. 35486	Black and white Black-and-white IR Color IR Thermal IR	70-mm (Thermal IR) 9- by 9-in. contact prints and positive transparencies	1:6,000-1:24,000	USDA, USGS, NASA, and commercial firms	Mobile Bay area, Alabama oil fields, and many widely scattered sites throughout state	1970-1974	As required in support of geologic investigations	Generally [illegible] dexes of [illegible] scales
Georgia	Georgia Dept. of Transportation Office of Location 2 Capitol Square Atlanta, Ga. 30334	Black and white Color Color IR	9- by 9-in. negatives roll positive transparencies	1:2,400-1:24,000 Predominant--1:6,000	In-house photo aircraft	Strip photography of existing and proposed highways. Block coverage of urban areas	1953-1975	As required	County high[illegible] maps. Ph[illegible] indexes [illegible] coverage[illegible]
Louisiana	Louisiana Dept. of Public Works Box 44155 Capitol St. Baton Rouge, La. 70804	Black and white	18- by 30-in. mosaics and 9- by 9-in. contact prints	1:20,000	Commercial firms	Red River--Arkansas border to Atchafalaya River	1944-1975	Annually	Informal ca[illegible]
	Louisiana Dept. of Highways P. O. Box 44245 Capitol St. Baton Rouge, La. 70804	Black and white	9- by 9-in. original negatives and contact prints	1:2,400-1:14,400	In-house photo aircraft	Along highway right-of-way prior to, during, and after construction	1962-1975	As required	Photo inde[illegible] Flight-li[illegible] (parish [illegible] cross-ind[illegible]
Mississippi	State Highway Dept. Transportation and Planning Section P. O. Box 1850 Jackson, Miss. 39205	Black and white	9- by 9-in. contact prints 17- by 17-in. enlargements	1:20,000-1:40,000	USDA and commercial firms	Statewide	1956-1975	As required	Photo and [illegible] indexes
	State Highway Dept. Roadway Design Div. P. O. Box 1850 Jackson, Miss. 39205	Black and white Color (near future)	9- by 9-in. contact prints	1:2,400-1:24,000	Commercial firms	All state and Federal proposed and existing highways	1958-1975	As required	Photo inde[illegible]
Tennessee	Dept. of Transportation 4113 Bldg. Vultee Blvd. Nashville, Tenn. 37217	Black-and-white	9- by 9-in. original negatives and contact prints	1:2,400-1:24,000	In-house photo aircraft and commercial firms	Along proposed and existing highways; full coverage of Shelby, Davison, Hamilton, and Knox Counties	1968-1975	As required	Coverage ar[illegible] plotted o[illegible] highway [illegible]

Table 13

State Agency Sources of Imagery

	Coverage				Acquisition			
					Reproduction			
	Period	Frequency	Indexing Method	Availability	In-House	Other	Intra-Agency Contact	Remarks
l al ain	1952-1975	As required	Photo indexes and county maps	Not generally available to other state or Federal agencies	None	--	Chief Engineer, Bureau of Surveys and Plans	
	1972-1975	As required for tax map revisions. Generally flown during leaf-off season	Photo indexes	Available	None	Contractor will reproduce copies of coverage.	Evaluation Supervisor, Mapping Section	
ns rs	1970-1974	As required in support of geologic investigations	Generally map indexes of various scales	Available	None	Potential users must make arrangements for reproduction of coverage desired.	Chief, Remote Sensing Div.	
l ras	1953-1975	As required	County highway maps. Photo indexes (block coverage)	Available	Yes; black-and-white and color	--	State Highway Location Engineer	Additional information concerning availability of aerial photography of the coastal zone of Georgia is contained in Technical Report Number 73-4, published by the Georgia Marine Science Center, Skidaway Island, Ga.
r-	1944-1975	Annually	Informal catalog	Available	None	Contractors hold original negatives.	Chief Engineer	
	1962-1975	As required	Photo indexes. Flight-line maps (parish maps) cross-indexed	Available	Yes	--	Director, Dept. of Highways	
	1956-1975	As required	Photo and map indexes	Available	Yes; black-and-white only	Contractors and USDA hold most original negatives.	Director of Highways	
s	1958-1975	As required	Photo indexes	Available	Yes; black-and-white only	--	Director of Highways	
ll nd	1968-1975	As required	Coverage areas plotted on county highway maps	Available	Yes (in near future); black-and-white only	--	Director, Aerial Surveys Div.	

Table 14

Sources of Commercial Remote Sensing Services in the Vicinity of the Mobile District

Aerial Photo Service, Inc.
324 Main Mall
Tulsa, Oklahoma 74103

Air Survey Corporation
Newton Square South
Reston, Virginia 22092

A&G Mapping Company
386 E. Maple Avenue
Vienna, Virginia 22180

Air Survey & Design, Inc.
8301 Arlington Blvd., Suite 1-1
Fairfax, Virginia 22030

Air Photographics, Inc.
Box 786
Purcellville, Virginia 22132

Anilas, Inc.
P. O. Box 1287
Salina, Kansas 67501

Atlantic Aerial Surveys, Inc.
803 Franklin Street, SE
Huntsville, Alabama 35801

Bosworth Aerial Surveys, Inc.
Lake Worth, Florida 33461

Chicago Aerial Survey
2140 Wolf Road
Des Plaines, Illinois 60018

Color Technique, Inc.
100 East Ohio Street
Chicago, Illinois 60611

Continental Aerial Surveys, Inc.
P. O. Box 335
Alcoa, Tennessee 37701

Danner & Associates
2406 E. University Avenue
Urbana, Illinois 61801

D&D Aero Spraying, Inc.
ATTN: Connie L. DeWald
Rantoul, Kansas 66079

Forrest L. Hicks
P. O. Box 487
Broadway, Virginia 22815

Gulf Coast Aerial Surveys, Inc.
4029 Plank Road
Baton Rouge, Louisiana 70805

M. J. Harden Associates, Inc.
1019 Admiral Blvd.
Kansas City, Missouri 64106

Henderson Aerial Surveys, Inc.
5125 West Broad Street
Columbus, Ohio 43228

International Aerial Mapping Company
8927 International Drive
San Antonio, Texas 78216

Kid-States Engineering Co., Inc.
107 N. Pennsylvania Street
Suite 703
Indianapolis, Indiana 46204

Kucera & Associates, Inc.
7000 Reynolds Road
Mentor, Ohio 44060

Legislative Council of Photogrammetry (2)
1001 Connecticut Avenue, N.W.
Suite 800
Washington, D. C. 20036

(Continued)

(Sheet 1 of 3)

Table 14 (Continued)

Mapcotec, Inc.
P. O. Box 5267
Daytona Beach, Florida 32020

Maps Incorporated
7677 Canton Center Drive
Baltimore, Maryland 21224

Allen Martin Productions, Inc.
9701 Taylorville Road
Louisville, Kentucky 40299

Mead Technological Laboratories
Precision Photographic Services
3481 Dayton-Xenia Road
Dayton, Ohio 45432

National Air Survey Center
1303 Gallaudet Street, N.E.
Washington, D. C. 20002

Owen & White, Inc.
P. O. Box 66396
7417 Jefferson Highway
Baton Rouge, Louisiana 70806

Parks Aerial Survey, Inc.
P. O. Box 21379
Louisville, Kentucky 40221

Photo Science, Inc.
7840 Airpark Road
Gaithersburg, Maryland 20760

Phototechnique, Inc.
2321 Fourth Street N.E.
Washington, D. C. 20002

Piedmont Aerial Surveys, Inc.
P. O. Box 11026
Greensboro, North Carolina 27409

E. S. Preston Associates, Inc.
939 Goodale Blvd.
Columbus, Ohio 43212

Raytheon Company-Autometric
Operation
Alexandria, Virginia

Ron Warner & Associates, Inc.
20 N. W. 38th Street
Oklahoma City, Oklahoma 73105

Sabre Exploration Corporation
P. O. Box 426
551 Wright Brothers Drive
Addison, Texas 75001

The Sidewell Company
Sidewell Park
28 West 240 Avenue
West Chicago, Illinois 60185

Surdex Corporation
25 Mercury Boulevard
Chesterfield, Missouri 63107

Joe J. Tamasko
124 Cotton Avenue
Birmingham, Alabama 35211

Texas Instruments Ecological Services
P. O. Box 5621, MS: 949
Dallas, Texas 75222
(Mr. F. J. (Buck) Melyer)

Tobin Surveys, Inc.
114 Camp Street
P. O. Box 2101
San Antonio, Texas 78206

Toler Aerial Mapping Service
Route 2, Box 747
Odessa, Texas 79780

United Aerial Mapping
5411 Jackwood Drive
San Antonio, Texas 78288

(Continued)

Table 14 (Concluded)

Wallace Aerial Surveys, Inc.
1415 College
P. O. Box 476
S. Houston, Texas 77587

Clyde E. Williams & Associates
1902 N. Sheridan Avenue
South Bend, Illinois 46628

Williams-Stackhouse & Associates
ATTN: R. V. Williams
2118 Mannix Drive
San Antonio, Texas 78217

Pan American Surveys, Inc.
8755 Southwest 131 Street
Miami, Florida 33156

Table 15

Selected Universities in the Mobile District Area Maintaining Remote Sensing Programs or Laboratories

School	Remote Sensing Facility/Program	Area(s) of Major Applications
Louisiana State University	Remote Sensing Center Baton Rouge, La. 70803	Multidisciplinary
University of Miami	Remote Sensing Laboratory P. O. Box 248003 Coral Gables, Fla. 33124	Meteorology Oceanography Air and water pollution Water resources
Oklahoma State University	Center for Applications of Remote Sensing Stillwater, Okla. 74074	Multidisciplinary
University of Tennessee Space Institute	Remote Sensing Laboratory Tullahoma, Tenn. 37388	Multidisciplinary
Texas A&M University	Remote Sensing Center College Station, Tex. 77843	Multidisciplinary

Table 16

Sources, Availability, and Operational Characteristics of U. S. Government K

Aircraft in the Mobile District Area and Vicinity

Agency/Department	Organization	Aircraft: Type	Aircraft: Svc Ceiling	Aircraft: Speed	Aircraft: Range	Aircraft: Endurance	Aircraft: Other	Sensors: Cameras	Sensors: Scanners	Sensors: Other	
U. S. Department of Agriculture	Agriculture Research Service Citrus Insects Lab 509 West 4th Street Weslaco, Tex. 78596	Cessna 182-J	30,000 ft	139 knots maximum cruising	900 miles	6.5 hours with long range tanks	Single reciprocating engines turbocharged	KA-2 9-in. format 12-in. F.L. Spectral Data Multispectral 9-in. format 6-in. F.L. KA-38 9- × 18-in. format 12-in. F.L.	None	None	Ai
	Forest Service Region 8 1720 Peachtree Road, N.W. Atlanta, Ga. 30309	Beechcraft B-99	25,000 ft	220 knots maximum cruising	1040 miles	4 hours	Twin turboprop engines	Wild RC-10 9-in. format 6-in. F.L. Vertical	None	None	Ai
		Rockwell Aero Commander 500-B	18,000 ft	160 knots maximum cruising	830 miles	4.5 hours	Twin reciprocating engines	Wild RC-10 9-in. format 6-in. F.L. Vertical			
U. S. Department of Commerce	National Oceanic and Atmospheric Administration (NOAA)	Lockheed C-130B	35,000 ft	280 knots TAS	2500 miles	9 hours	Four turboprop engines	Configured for cameras up to 70mm	None	Numerous environmental and meterological monitoring systems, and Barnes PRT-5 radiometer (downward and side-looking configurations)	Ai
	Environmental Research Laboratories (ERL) Research Facilities Center P. O. Box 480197 Miami, Fla. 33148	Lockheed WP-3D Orion	30,000 ft	325 knots TAS	2300 miles	7 hours	Four turboprop engines				
U. S. Energy Research and Development Administration (ERDA)	Division of Safety, Standards and Compliance Washington, D. C. 20545	Beechcraft A-100 King Air	25,000 ft	230 knots cruising	1300 miles	5 hours	Twin turboprop engines	Hasselblad 500 EL (4 lens) 70mm	Bendix TM/LN-3 Thermal Mapper 0.2 - 0.7 microns 3-5.5 microns 8-14 microns	<u>Meteorological</u>: Time, temperature, wind speed, wind direction, dew point <u>Positioning</u>: Pressure altitude, radar altitude, mag. heading, Doppler radar <u>Radiation</u>: NaI crystal array for gamma ray detection Bf^3 Tube for neutron activity Silicon diodes for	Ai
		Martin 404	25,000 ft	195 knots cruising	1400 miles	6 hours	Twin reciprocating engines				
		Beechcraft E-50 Twin Bonanza	20,000 ft	130 knots cruising	600 miles	4 hours	Twin reciprocating engines				
		Hughes 500-C (helicopter)	15,800 ft	130 knots cruising, with sensors 87 knots cruising	110 miles with sensors	1 hour, 10 min	Single turbine engine				
National Aeronautics and Space Administration (NASA)	Earth Resources Laboratory 1010 Gause Road Slidell, La. 70458	Beechcraft E-18S	10,000 ft	110-180 knots (TAS)	800 miles	5.8 hours	Twin reciprocating engines	1-I^2S Multiband (4 images) 2-Hasselblad 500 EL 70mm 1-KC-1B 9-in. format 6-in. F.L.	1-RS-18 Thermal IR Radiometer 5 channels	1-E-20-D Spectral Radiometer 1-PRT-5 Thermal Radiometer 1-L-Band Microwave Radiometer	Th
	Lyndon B. Johnson Space Center Flight Operations Division CC-43 Houston, Tex. 77058	Lockheed NP-3A WP-3D	30,000 ft	150-330 knots (TAS)	2000 miles	7 hours	Four turboprop engines	M^2S Multiband (4 images) Zeiss Metric 9.5-in. format, 6-in. F.L.	Bendix Modular multispectral scanner 11 channels	MFMR Passive multi-frequency PMIS, microwave PRT-5 Radiometer Laser Profiler	Th
		Lockheed Hercules NC-130B	30,000 ft	159-292 knots (TAS)	2500 miles	10 hours	Four turboprop engines	--	--	Scatterometers, 0.4, 1.6, and 13.3 S.P. Gh3 PRT-5 Radiometer Laser Profiler	
		Martin WB-57	60,000 + ft	400 knots TAS at 60,000 ft	2500 miles	5 hours	Twin turbofan engines with two auxillary turbojet (J-60) engines	--	RS-18 Thermal IR Radiometer	--	
Tennessee Valley Authority (TVA)	Maps and Surveys Br. Imagery Acquisition Unit 200 Haney Building Chattanooga, Tenn. 37401	Beechcraft A-11	19,000 ft	150 knots cruising	700 miles	4 hours	Twin reciprocating engines	1-RC-8 6-in. F.L. 9-in. format 4-Hasselblad 500 EL 70mm Quad-mounted	Deadalus Thermal IR Two detectors 4-5.5 microns 8-13 microns	None	Th

Table 16

, and Operational Characteristics of U. S. Government Remote-Sensing

ircraft in the Mobile District Area and Vicinity

Sensors						
eras	Scanners	Other	Availability	Costs	Mission Requests	Remarks
format F.L. al Data pectral format F.L. 8-in. at F.L.	None	None	Aircraft is generally available for support of research projects only. Availability of aircraft is also dependent on ARS workload	$15.00 per hour - aircraft only	Contact: Mr. William G. Hart Research Leader USDA ARS Citrus Insects Lab Weslaco, Tex. 78596 Ph. 512-968-7822	
C-10 format F.L. al C-10 format F.L. al	None	None	Aircraft are available for support of other agencies dependent on Forest Service workload	$100.00 per hour for missions of short duration. $149.00 per hour for missions of extended periods. Rates applicable for both aircraft. Photographer, GS-11, extra. Rates do not include film and processing.	Contact: Mr. D. W. Myler Chief, Air Management Office U. S. Forest Service Region 8 1720 Peachtree Road, N.W. Atlanta, Ga. 30309 Ph. 285-2401 (FTS)	
ured for ras up to	None	Numerous environmental and meterological monitoring systems, and Barnes PRT-5 radiometer (downward and side-looking configurations)	Aircraft are generally available for mission support to other agencies	Costs are highly variable and are dependent on aircraft/sensor mix, data desired, etc. The P-3 aircraft are currently costing about $900.00 per hour to fly missions of the type for which the on-board sensor array is designed.	Obtain NOAA Form 85-501, "Request for RFC Support." The form is available from: NOAA/RFC P. O. Box 480197 Miami, Fla. 31148 Ph. (305) 526-2936 Submit completed form to: Director Weather Modification Programs Ofc NOAA/Environmental Research Laboratories (ERL), RX9 Boulder, Colo. 80302	Mission requests are normally forwarded to the Director, RFC and the NOAA Aircraft Allocation Committee (NAAC) for review. The RFC can be formally committed to support a mission program only by the NAAC or the Director, ERL.
blad 500 lens)	Bendix TM/LN-3 Thermal Mapper 0.2 - 0.7 microns 3-5.5 microns 8-14 microns	<u>Meteorological</u>: Time, temperature, wind speed, wind direction, dew point <u>Positioning</u>: Pressure altitude, radar altitude, mag. heading, Doppler radar <u>Radiation</u>: NaI crystal array for gamma ray detection Bf^3 Tube for neutron activity Silicon diodes for	Aircraft are available for support of work conducted by other agencies	Reimbursable costs for use by aircraft can be calculated only after the mix of equipment is known and the degree of schedule integration of ERDA and non-ERDA missions is determined.	Contact: Mr. L. Joe Deal Assistant Director for Health Protection Division of Safety, Standards, and Compliance HS ERDA Washington, D. C. 20545	ERDA aircraft and sensors are used in Aerial Radiological Measuring Systems (ARMS) Programs. This program maintains a state-of-the-art nuclear radiation measurement capability for economically conducting large area ground deposition surveys, for rapid assessment of radiological emergencies, and for location of lost radiation sources.
ultiband ages) lblad L format F.L.	1-RS-18 Thermal IR Radiometer 5 channels	1-E-20-D Spectral Radiometer 1-PRT-5 Thermal Radiometer 1-L-Band Microwave Radiometer	This aircraft is generally available for support of other agency missions if the nature of the mission is analogous with the primary *mission of the Earth Resources* Lab: acquisition of data for support of research projects concerned with the development and experimental demonstration of the uses of remotely sensed data acquired from aircraft and satellites.	--	Contact: Mr. Wayne Mooneyhan Director Earth Resources Laboratory 1010 Gause Road Slidell, La. 70458	
tiband ages) etric n. for- 6-in. - -	Bendix Modular multispectral scanner 11 channels -- RS-18 Thermal IR Radiometer	MFMR Passive multi-frequency PMIS, microwave PRT-5 Radiometer Laser Profiler Scatterometers, 0.4, 1.6, and 13.3 S.P. Gh3 PRT-5 Radiometer Laser Profiler --	These aircraft are generally available for support of certain programs conducted by other government agencies. A strong research justification, however, is currently required by NASA before use of aircraft can be obtained.	--	Submit requests to: NASA/Ames Research Center Airborne Application Support Program Office Code SP-240-5 Moffett Field, Calif. 94035	<u>Note</u>: Aircraft/sensor configurations listed are those <u>tentatively</u> scheduled for FY 1977.
F.L. format lblad L nted	Deadalus Thermal IR Two detectors 4-5.5 microns 8-13 microns	None	This aircraft is generally available for support of other agency missions, dependent upon TVA wordload.	$375.00 per day basic charge, plus $100.00 per flying hour	Contact: Mr. William S. Massa Chief, Maps and Surveys Branch TVA 200 Haney Building Chattanooga, Tenn. 37401	

Table 17

Sources, Availability, and Operational Characteristics of Department of Defense Reconnaissance

Department	Organization	Aircraft: Type	Svc Ceiling	Speed	Range	Endurance	Other	Sensors: Cameras: Station 1	Station 2	Station 3	Scanners: Station 5
Department of the Air Force	Tactical Air Command (TAC) 9th Air Force 363rd Tactical Reconnaissance Wing (TRW) Shaw, AFB, S. C. 29152 12th Air Force, 67th TRW, Bergstrom AFB, Tex. 78743	McDonnell Douglas RF-4C Phantom II	Over 50,000 ft	1600 knots maximum cruising	2300 miles (ferry range)	--	Twin turbojet engines	KS-87 3-in. F.L. oblique (forward) frame KS-87 3- and 6-in. F.L. vertical frame KS-87 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic KS-87 3-in. F.L. vertical frame KS-72 (2) 3-in. F.L. oblique (L and R) frame KS-87 (2) 6-in. F.L. oblique (L and R) frame KS-87 12- and 18-in. F.L. oblique (L and R) frame KA-1 24- and 36-in. F.L. vertical frame	T-11 6-in. F.L. vertical frame KS-87 (2) 6- and 18-in. F.L. vertical (split) frame KS-87 18-in. F.L. vertical frame KA-91 18-in. F.L. vertical panoramic--60° or 93° scan	AN/AAS-18 IR mappin system
Department of the Air Force Air National Guard	Alabama Air National Guard 117th TRW, 106th TRS Birmingham Municipal Airport Birmingham, Ala. 35217 187th TRG Dannelly Field Montgomery, Ala. 36105	McDonnell Douglas RF-4C Phantom II	Over 50,000 ft	1600 knots maximum cruising	2300 miles (ferry range)	--	Twin turbojet engines	KS-72 3-in. F.L. oblique (forward) frame KS-72 3- and 6-in. F.L. vertical frame KS-72 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic KS-72 3-in. F.L. vertical frame KS-72 (2) 3-in. F.L. oblique (L and R) frame KS-72 (2) 6-in. F.L. oblique (L and R) frame KS-72 12- and 18-in. F.L. oblique (L or R) frame KA-1 24- and 36-in. F.L. vertical frame	T-11 6-in. F.L. vertical frame KA-55 12-in. F.L. vertical frame KS-72 (2) 6- and 18-in. F.L. vertical (split) frame KS-72 18-in. F.L. vertical frame	AN/AAS-18 IR mappin system
	Kentucky Air National Guard 123rd TRW, Standiford Field Louisville, Ky. 40213	McDonnell Douglas RF-4C Phantom II	Over 50,000 ft	1600 knots maximum cruising	2300 miles (ferry range)	--	Twin turbojet engines	KS-72 3-in. F.L. oblique (forward) frame KS-72 3- and 6-in. F.L. vertical frame KS-72 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic KS-72 3-in. F.L. vertical frame KS-72 (2) 3-in. F.L. oblique (L and R) frame KS-72 (2) 6-in. F.L. oblique (L and R) frame KS-72 12- and 18-in. F.L. oblique (L or R) frame KA-1 24- and 36-in. F.L. vertical frame	T-11 6-in. F.L. vertical frame KA-55 12-in. F.L. vertical frame KS-72 (2) 6- and 18-in. F.L. vertical (split) frame KS-72 18-in. F.L. vertical frame	AN/AAS-18 IR mappin system

(Continued)

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onal Characteristics of Depar:ment of Defense Reconnaissance Aircraft ir the Mobile District Area

er	Sensors: Cameras: Station 1	Cameras: Station 2	Cameras: Station 3	Scanners: Station 5	Other: Station 4	Availability	Costs	Mission Requests	Remarks
bojet s	KS-87 3-in. F.L. oblique (forward) frame KS-87 3- and 6-in. F.L. vertical frame KS-87 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic KS-87 3-in. F.L. vertical frame KS-72 (2) 3-in. F.L. oblique (L and R) frame KS-87 (2) 6-in. F.L. oblique (L and R) frame KS-87 12- and 18-in. F.L. oblique (L and R) frame KA-1 24- and 36-in. F.L. vertical frame	T-11 6-in. F.L. vertical frame KS-87 (2) 6- and 18-in. F.L. vertical (split) frame KS-87 18-in. F.L. vertical frame KA-91 18-in. F.L. vertical panoramic--60° or 93° scan	AN/AAS-18 IR mapping system	AN/APQ-102 side-looking airborne radar system (SLAR)	Aircraft of the 67th and 363rd TRW's are generally available for mission support to other governmental and/or military organizations.	No firm cost data are available since costs are highly variable and dependent upon type of mission, time, size of area, etc. However, in most instances, costs may be limited to crew per diem if the mission can be accomplished under training ~rograms.	Mission requests should be submitted as follows: U. S. Government agencies: Headquarters, TAC ATTN: DOOR Langley, AFB, Va. U. S. Army elements: Headquarters, DA ATTN: DAMI-TSS-R Washington, D. C. 20310 U. S. Air Force elements: In accordance with AFR 95-8	The 363rd TRW prefers to limit mission support to that part of the CONUS located east of the Mississippi River. The 67th TRW prefers to limit mission support to that part of the CONUS located west of the Mississippi River. All Air Force activities, Federal, or DOD agencies may request mission support. To non-Federal government agencies (state, county, and local governments), support is limited to national or civil emergency requirements. It is recommended that all activities review Air Force Regulation 95-8 before initiating requests for aerial missions.
bojet s	KS-72 3-in. F.L. oblique (forward) frame KS-72 3- and 6-in. F.L. vertical frame KS-72 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic KS-72 3-in. F.L. vertical frame KS-72 (2) 3-in. F.L. oblique (L and R) frame KS-72 (2) 6-in. F.L. oblique (L and R) frame KS-72 12- and 18-in. F.L. oblique (L or R) frame KA-1 24- and 36-in. F.L. vertical frame	T-11 6-in. F.L. vertical frame KA-55 12-in. F.L. vertical frame KS-72 (2) 6- and 18-in. F.L. vertical (split) frame KS-72 18-in. F.L. vertical frame	AN/AAS-18 IR mapping system	AN/APQ-102 SLAR	Aircraft are generally available for mission support to other agencies.	Generally, no cost is charged to user, except possible crew per diem during extended missions. This policy is applicable only when missions can be accomplished as a part of training program.	Submit mission requests to: The Adjutant General's Office State Military Department (AFAB), Montgomery, Ala. 36103	Normally, the Air National Guard units prefer to stage missions that are within flying range of their home bases. This policy is not inflexible, however, and most units will consider conducting missions in areas located at longer distances from their bases.
bojet s	KS-72 3-in. F.L. oblique (forward) frame KS-72 3- and 6-in. F.L. vertical frame KS-72 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic KS-72 3-in. F.L. vertical frame KS-72 (2) 3-in. F.L. oblique (L and R) frame KS-72 (2) 6-in. F.L. oblique (L and R) frame KS-72 12- and 18-in. F.L. oblique (L or R) frame KA-1 24- and 36-in. F.L. vertical frame	T-11 6-in. F.L. vertical frame KA-55 12-in. F.L. vertical frame KS-72 (2) 6- and 18-in. F.L. vertical (split) frame KS-72 18-in. F.L. vertical frame	AN/AAS-18 IR mapping system	AN/APQ-102 SLAR	Aircraft are generally available for mission support to other agencies.	Generally, no cost is charged to user, except possibly crew per diem during extended missions. This policy is applicable only when missions can be accomplished as a part of training program.	Submit mission requests to: The Adjutant General Kentucky Department of Military Affairs Boone National Guard Center Frankfort, Ky. 40601	

(Continued)

Table 17 (Continued)

Department	Organiztion	Aircraft: Type	Svc Ceiling	Speed	Range	Endurance	Other	Sensors: Cameras: Station 1	Station 2	Station 3	Scanners: Station 5
Department of the Air Force Air National Guard (Continued)	Mississippi Air National Guard, 186th TRG P. O. Box 1825 Meridian, Miss. 39301	McDonnell Douglas RF-101C Voodoo	40,000 ft	474 knots average cruising	1,755 miles	2 hours with standard tanks	Twin turbojet engines	KS-72 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic	KS-72 3-in. F.L. vertical (split) frame KS-72 6-in. F.L. vertical (split) frame KS-72 18-in. F.L. vertical (split) frame Also: KA-1 24- and 36-in. F.L. vertical frame	None
Department of the Army U. S. Army	13th Aviation Battalion (*Combat*) 131st Military Intelligence Company (Aerial Surveillance) Ft. Hood, Tex. 76544	Grumman OV-1D Mohawk	25,000 ft (80 percent fuel)	240 knots maximum cruising	1,000 miles with external tanks, at 20,000 ft	4.0 hours	Twin turboprop engines	KA-60C 3-in. F.L. oblique (forward) panoramic	KA-60C 3-in. F.L. vertical panoramic	KA-76A 1.75-, 3-, 6-, and 12-in. F.L. oblique (L or R) vertical (in flight rotatable frame	AN/AAS-24 IR
Department of the Army National Guard	Georgia National Guard 151st Aviation Battalion 158th Military Intelligence Company Winder, Ga. 159th Military Intelligence Company Dobbins AFB, Ga.	Grumman OV-1B OV-1C Mohawk	25,000 ft	B-model 240 knots maximum cruising C-model 258 knots maximum cruising	B-model 1,200 miles with external tanks C-model 1,330 miles with external *tanks*	3 to 4 hours	Twin turboprop engines		Cameras KA-30 1.75-, 3-, 6-, and 12-in. F.L. oblique (L or R) vertical frame KA-60B 3-in. F.L. vertical panoramic KA-76A Same as other 76A's	Note: B-model carries only KA-30 Early C-models carry KA-30, later models carry KA-76	Scanners AN/AAS-14 IR
Department of the Navy U. S. Navy	Reconnaissance Attack Wing 1 Naval Air Station Key West, Fla. 33040	North American Rockwell RA-5C Vigilante	Over 50,000 ft	Mach 2 maximum cruising	--	--	Twin turbojet engines	KA-51 6-in. F.L. oblique (forward) frame	KA-50 1.75-in. F.L. vertical frame KA-51 6-in. F.L. vertical frame KA-62 3-in. F.L. vertical frame	Station 4 (Module 1) KA-50 (2) KA-51, or KA-62 6-in. F.L. oblique (L and R) frame KA-57 (KS-68) 3-in. F.L. vertical panoramic KA-53 (2) 6-in. F.L. oblique (L and R) frame Station 4 (Module 2) KA-57 (KS-68) 3-in. F.L. vertical panoramic KA-58 (KS-69) 18-in. F.L. vertical panoramic Station 4 (Module 3) KA-50 (2), KA-51, or KA-62 6-in. F.L. vertical frame (night) KA-53 (2) 12-in. F.L. vertical (split) frame	Station 7 AN/AAS-21 IR

(Continued)

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Table 17 (Continued)

	Sensors								
er	Cameras			Scanners	Other	Availability	Costs	Mission Requests	Remarks
	Station 1	Station 2	Station 3	Station 5	Station 4				
rbojet s	KS-72 6-in. F.L. oblique (forward) frame	KA-56 3-in. F.L. vertical panoramic	KS-72 3-in. F.L. vertical (split) frame KS-72 6-in. F.L. vertical (split) frame KS-72 18-in. F.L. vertical (split) frame Also: KA-1 24- and 36-in. F.L. vertical frame	None	None	Aircraft are generally available for mission support to other agencies.	Some costs may be incurred if mission involves cross-country flights where various bases are used for staging.	Submit mission requests to: The Adjutant General P. O. Box 5027 Foundren Station Jackson, Miss. 39216	
rboprop es	KA-60C 3-in. F.L. oblique (forward) panoramic	KA-60C 3-in. F.L. vertical panoramic	KA-76A 1.75-, 3-, 6-, and 12-in. F.L. oblique (L or R) vertical (in flight rotatable frame	AN/AAS-24 IR	AN/APS-94D SLAR	Aircraft are generally available for mission support to other governmental and military organizations.	No firm cost data is available. Costs can generally be held to a minimum level if mission support is conducted as part of overall training program.	Submit mission requests to: Commanding General Headquarters, 3rd Corps Ft. Hood, Tex. 76544 ATTN: G-2 AF/ZF-DS-AD	
rboprop es		Cameras		Scanners	Other	Aircraft are generally available for mission support to other governmental and military organizations.	No firm cost data is available. Costs can generally be held to a minimum level if mission support is accomplished as part of training program.	Submit mission requests to: Office of the Adjutant General Military Division P. O. Box 17965 Atlanta, Ga. 30316	
		KA-30 1.75-, 3-, 6-, and 12-in. F.L. oblique (L or R) vertical frame KA-60B 3-in. F.L. vertical panoramic KA-76A Same as other 76A's	Note: B-model carries only KA-30 Early C-models carry KA-30, later models carry KA-76	AN/AAS-14 IR	AN/ APS-94C				
rbojet s	KA-51 6-in. F.L. oblique (forward) frame	KA-50 1.75-in. F.L. vertical frame FA-51 6-in. F.L. vertical frame KA-62 3-in. F.L. vertical frame	Station 4 (Module 1) KA-50 (2) KA-51, or KA-62 6-in. F.L. oblique (L and R) frame KA-57 (KS-68) 3-in. F.L. vertical panoramic KA-53 (2) 6-in. F.L. oblique (L and R) frame Station 4 (Module 2) KA-57 (KS-68) 3-in. F.L. vertical panoramic KA-58 (KS-69) 18-in. F.L. vertical panoramic Station 4 (Module 3) KA-50 (2), KA-51, or KA-62 6-in. F.L. vertical frame (night) KA-53 (2) 12-in. F.L. vertical (split) frame	Station 7 AN/AAS-21 IR	Station 8 AN/ APD-7 SLAR	Aircraft are generally available for mission support to other governmental and military agencies. Availability of RAW-1 aircraft is generally restricted to limited missions in the south and southeastern regions of the U. S. However, more extensive missions can be supported if a strong justification can be presented.	Normally, missions can be flown at no cost to the requestor if missions are conducted as part of unit training program.	Requests for missions of a limited nature located in the southern and southeastern U. S. should be forwarded to: Commander, Reconnaissance Attack Wing 1, NAS Key West, Fla. 33040 Requests for missions of a more extensive nature, e.g., large, remote areas, should be directed to: Commander, Naval Air Force U. S. Atlantic Fleet Norfolk, Va. 23511	

(Continued)

Table 17 (Concluded)

Department	Organization	Aircraft: Type	Aircraft: Svc Ceiling	Aircraft: Speed	Aircraft: Range	Aircraft: Endurance	Aircraft: Other	Sensors: Cameras: Station 1	Sensors: Cameras: Station 2	Sensors: Cameras: Station 3	Sensors: Scanners: Station 5
Department of the Navy U. S. Naval Reserve	VFP-206, VFP-306 Naval Air Facility Washington, D. C. 20390	LTV RF-8G Crusader	40,000 ft (photo limit)	Mach 2 maximum cruising	1,100 miles	--	Single turbo-jet engine	KA-45 6-in. F.L. oblique and vertical frame; KA-51 6-in. F.L. oblique (forward) frame		KA-62 3-in. F.L. vertical frame; KA-53 12-in. F.L. vertical (split) frame; KA-66 3-in. F.L. vertical panoramic	None

Table 17 (Concluded)

Sensors								
Cameras			Scanners	Other	Availability	Costs	Mission Requests	Remarks
Station 1	Station 2	Station 3	Station 5	Station 4				
KA-45 6-in. F.L. oblique and vertical frame KA-51 6-in. F.L. oblique (forward) frame		KA-62 3-in. F.L. vertical frame KA-53 12-in. F.L. vertical (split) frame KA-66 3-in. F.L. vertical panoramic	None	None	Aircraft are generally available for mission support to other governmental and military organizations.	There are generally no costs involved for missions of a limited scope in the Washington, *D. C.*, area. More extensive missions in this area may require funding of crew and fuel costs. Missions conducted over areas that are located long distances from Washington will normally cost from $310.00 to $320.00 per flying hour, plus crew expenses. Crew expenses may be eliminated if a suitable air base for staging is located near the area to be flown.	Requests for missions should be forwarded to: *Chief, U. S. Naval Reserve* New Orleans, La. 70146	

(Sheet 3 of 3)

Table 18

Factors Affecting Cost of Aerial Photography

- Weather
- Location of Area
- Size of Area
- Mobilization-Demobilization Costs
  - Logistical Support
    - Fuel, Oil, Maintenance, Clearances, Parts, Film
    - Processing, Permits, Customs, Living Accommodations
  - Personnel
    - Aircraft Crew
    - Photo Technician
    - Project Manager
- Scale of Photos
  - Costs increase as Scale increases
- Type of Photography

Table 19

Cost of Imagery Obtained From Photographic Systems

Imagery Type	Altitude, ft	Scale	Cost/Square Mile dollars	Source Reference No.
Panchromatic B&W	15,000-20,000	1:30,000-1:40,000	2.00-4.50	12
and	7,500-10,000	1:15,000-1:20,000	3.00-7.50	12
Infrared B&W	25,000	1:50,000	0.77-1.16	*
	10,000	1:20,000	1.50-1.93	*
	5,000	1:10,000	3.47-4.25	*
	12,000	1:24,000	3.58	13
	6,000	1:12,000	10.83	13
	3,000	1: 6,000	39.70	13
Color and Color IR	15,000-20,000	1:30,000-1:40,000	3.50-10.000	12
	3,000	1: 6,000	83.70	13

* Costs obtained from Mr. Pat O'Neil, USDA, U. S. Geological Survey, NSTL, Bay St. Louis, Mississippi, in private communications.

Table 20

Synopsis of Available Aircraft and Remote Sensors from Agencies of States Near or In the Mobile District

State	Organization	Aircraft	Sensors	Other
Alabama	--	None	None	Contract
Florida	Department of Transportation Aerial Surveys Section Hayden Burns Building Tallahassee, Florida 32304	Rockwell Aero Commander 680-FL	Zeiss RMKA 15/23, 6-in. F.L.	--
		Rockwell Aero Commander 500	Wild RC-8, 6-in. F.L. 123 Multispectral	--
Georgia	Department of Transportation Aerial Surveys Laboratory 65 Aviation Circle Atlanta, Georgia 30336	Rockwell Aero Commander 680 FL	Wild RC-8, 6-in. F.L.	--
		Rockwell Aero Commander 685	Wild RC-10, 6-in. F.L. Fairchild K-17, 12-in. F.L.	--
Louisiana	State Highway Department Location and Survey Section Photogrammetric Unit P. O. Box 44245, Capitol Station Baton Rouge, Louisiana 70804	Piper Aztec	Wild RC-8, 6-in. F.L.	--
Tennessee	Department of Transportation Aerial Surveys Division 4113 Building, Vultee Boulevard Nashville, Tennessee 37217	Rockwell Aero Commander 680 FL	Zeiss RMK 15/23, 6-in. F.L.	--
Texas	State Department of Highways and Public Transportation, Division of Automation Photogrammetry Section 38 and Jackson Streets Austin, Texas 78731	Cessna 206 (2)	Wild RC-8 (2), 6-in. F.L. K&E, 12-in. F.L.	--

(Continued)

Table 20 (Concluded)

State	Organization	Aircraft	Sensors	Other
Texas	Texas Forest Service College Station, Texas 77843	DeHavilland Beaver	Zeiss RMK 15/23, 6-in. F.L.	--
			Hasselblad 500 ELMS, 70mm, quad-mounted	--

Table 21

Guidelines for Aerial Surveys

Description of Task	Film Type	Season	Scale
Forest mapping: conifers	Pan	Fall, winter	1:12,000-1:20,000
Forest mapping: mixed stands	IR	Late spring, fall	1:10,000-1:12,000
Timber volume estimates	Pan or IR	Spring, fall	1:5,000 -1:20,000
Locating property boundaries	Pan	Late fall, winter	1:10,000-1:25,000
Measuring areas	Pan	Late fall, winter	All scales
Topographic mapping; highway surveys	Pan	Late fall, winter	1:5,000 -1:10,000
Urban planning	Pan	Late fall, winter	1:4,800 -1:9,600
Automobile traffic studies	Pan	All seasons	1:2,400 -1:6,000
Surveys of wetlands or tidal regions	IR	All seasons - low tide	1:5,000 -1:30,000
Archeological explorations	IR	Fall, winter	1:2,400 -1:20,000
Identifying tree species	Color	Spring, summer	1:600 -1:4,800
Assessing insect damages	Color IR	Spring, summer	1:600 -1:5,000
Assessing plant diseases	Color IR	Spring, summer	1:1,200 -1:7,200
Water resources and pollution	Multispectral	All seasons	1:4,800 -1:8,000
Agricultural soil surveys	Color	Spring or fall, after plowing	1:4,800 -1:8,000
Mapping range vegetation	Color	Summer	1:600 -1:2,400
Real estate assessment	Color negative	Late fall, winter	1:4,800 -1:12,000
Industrial stockpile inventories	Color negative	All seasons	1:1,200 -1:4,800
Recreational surveys	Color negative	Late fall, winter	1:5,000 -1:12,000

Note: Color aerial photography can also be used, often to greater advantage than black-and-white photography.

Table 22

Aerial Film Defects and Causes[14]

Defect		Description	Cause	Prevention
Blurred negatives	Overall	Halo effect surrounding image point.	Condensation on lens	Fly low altitude runs before high altitude runs, or descend from high altitude at maximum of 1000 ft per 3 min.
		Double image	Vibration of camera	Cushion camera against plane vibration.
		Longitudinal streaks of image points parallel to flight lines.	Movement of image	Use proper shutter speed for low altitude and speed of plane.
			Plane altitude near hyperfocal distance of camera.	Maintain plane altitude beyond hyperfocal distance of camera.
		Image out of focus (most likely to occur at large lens apertures).	Incorrect setting for type of film, or correct setting altered during camera repairs.	Correct setting. Repair and correct camera.
		Fog-overall or local veiling resulting in low contrast; whites are a dirty grey.	Overage film, impure developer, forced development, improper safelight, dirty lens.	
			Overexposure, often combined with under-development.	
	Localized	Local blurring (part blurred, remainder sharp). Wavy image.	Failure or partial failure to vacuum (camera).	
			Dirt on platen or vacuum back, or objects preventing film from proper contact with pressure plate.	
Lack of sharpness		Poor definition of image (poor definition of lens).	Incorrect solar altitude.	
			Terrain peculiarities.	
			Use of incorrect filters.	
		Coarse graininess of negative (degree of visibility of silver grains of developed negative as determined by the relative size of the grains).	Inherent emulsion structure. (Fast film sacrifices fine grain for speed.)	
			Type of developer.	
			Length of development.	
Large areas of varying density		Longitudinal parallel areas of unequal tone.	Uneven development of negative.	
			Overloading film capacity of developing unit.	
		Irregular areas of varying tone	Uneven development of fixation	Use ample chemical solutions to cover all of film.
			Negative partially immersed in developer or fixing bath.	
		Large or small blank areas on negative.	Obstruction in front of camera	Keep camera front clear of obstructions.
		Rectangular grid pattern on negative	Moisture on film in a vacuum type camera back.	
Small spots or streaks		Light spots appear on prints in shape of water drops.	Water spots drying on negative; moisture condensing on undeveloped film.	Adjust air squeegee or wiper blade to remove excess liquids.
		Dark spots on negative	----------	Store film (undeveloped) in cool, dry spot.
		Small round white spots on negative or small round dark spots on prints.	Air bells on film preventing developer from acting on film.	Agitate film properly during development.
		Spots with diffused edges, often with tails	Incompletely dissolved developer chemicals sticking to film.	Mix chemicals properly and agitate film properly during development.
		Irregular clear spots	Scum from developer surface adhering to film, preventing access of developer to emulsion.	Properly agitate film during development.
			Chemicals of solutions touching film before development.	
	Abrasion of film	Fine parallel or streaks on film (fine light parallel lines or streaks on print).	Abrasion of film by sharp objects during film rewind in camera.	Keep camera free of dirt and grit.
			Abrasion of base side creates an opaquing effect.	
		Fine light lines or streaks on film (fine dark lines or streaks on print).	Abrasion of film after development	Handle film carefully.
			Careless rolling and unrolling of film.	
		Clear irregular areas on film (dark irregular areas on prints).	Cuts, gashes, and tears in emulsion after development.	Handle film carefully.
			Insufficient hardening, making emulsion soft and tacky.	
			Rolling film too tightly on roll, causing soft emulsion to stick and pull when unwound.	
Finger marks		Fingermarks on film (1) Light (2) Dark.	(1) Fingers touching emulsion before development, or (2) developer-contaminated fingers touching film before development.	Avoid touching emulsion side of film.

(Continued)

Table 22 (Concluded)

Defect		Description	Cause	Prevention
Other	Miscellaneous	Dark streaks combined with general fog.	Camera leak or improper safelight. (If edges clear--camera defect.)	
		Branching or fan-shaped dark mark-on film.	Static electric discharges on dry film caused by dry friction during or after very dry, cold weather.	Handle film gently in cold, dry weather.
		Network of lines, grainy leatherlike appearance.	Reticulated emulsion, caused by overage film, processing film without sufficient hardener, subjecting film to extreme changes in temperature while processing, or processing or drying film in excessively warm temperatures.	If caused by improper temperature during processing, maintain recommended temperatures while processing.
		Stretched and warped emulsion and backing.	Subjecting film to too much heat.	
		Torn negatives	Careless handling of film. Subjecting film to tension while titling. Old and brittle film. Deep scratches in film base. Jerking or forcing film over obstructions and bent spool. Crimping of film.	
		Frilling (separation of emulsion from base around edges).	Processing solutions excessively warm, or if wash water is warm and film is not properly hardened.	
		Blisters (appearing as small craterlike depressions in the emulsion).	Carbon dioxide gas liberated by chemical reactions of solution when temperature is above normal.	
		Creeping of emulsion	High temperature and insufficient ventilation during drying.	
		Fungus (usually appears in the gelatin backing).	Improper storage under warm, humid conditions.	

Table 23

Landsat Scenes Used to Produce Overlays Depicting Water Bodies 10 Acres and Greater

Scene No.	Landsat Identification No.	Date of Satellite Overpass	Coordinates of Center of Scanned Area: Latitude	Coordinates of Center of Scanned Area: Longitude
1	2749-15345	9 Feb 77	$34^{\circ}35'$N	$88^{\circ}25'$W
2	2748-15291	8 Feb 77	$34^{\circ}36'$N	$86^{\circ}57'$W
3	2747-15232	7 Feb 77	$34^{\circ}36'$N	$85^{\circ}33'$W
4	2746-15174	6 Feb 77	$34^{\circ}33'$N	$84^{\circ}08'$W
5	2749-15351	9 Feb 77	$33^{\circ}09'$N	$88^{\circ}50'$W
6	2730-15301	21 Jan 77	$33^{\circ}12'$N	$87^{\circ}21'$W
7	2747-15235	7 Feb 77	$33^{\circ}10'$N	$85^{\circ}59'$W
8	2746-15181	6 Feb 77	$33^{\circ}07'$N	$84^{\circ}34'$W
9	2749-15354	9 Feb 77	$31^{\circ}44'$N	$89^{\circ}15'$W
10	2730-15304	21 Jan 77	$31^{\circ}46'$N	$87^{\circ}46'$W
11	2747-15241	7 Feb 78	$31^{\circ}44'$N	$86^{\circ}24'$W
12	2746-15183	6 Feb 77	$31^{\circ}41'$N	$84^{\circ}59'$W
13	2749-15360	9 Feb 77	$30^{\circ}18'$N	$89^{\circ}40'$W
14	2730-15310	21 Jan 77	$30^{\circ}20'$N	$88^{\circ}11'$W
15	2765-15240	25 Feb 77	$30^{\circ}15'$N	$86^{\circ}52'$W
16	2746-15190	6 Feb 77	$30^{\circ}15'$N	$85^{\circ}24'$W

Note: Scene numbers correspond to those indicated in Figure 42.

Table 24

Total Surface Areas of Lakes and Streams in the States of the Mobile District

State	Area of Lakes, acres*	Area of Streams, acres
Alabama	229,447	219,988
Mississippi	75,392	53,431
Louisiana	640	3,044
Georgia	127,579	8,585

* The total surface area is given for all lakes 10 acres and greater.

APPENDIX A: DESCRIPTION OF OPTRONICS FILM READER/WRITER

1. Photographic transparencies depicting the interpreted terrain conditions are produced using an incremental film reader/writer (Figure A1). The film reader/writer is an electromechanical photograph-scanning

Figure A1. Film reader/writer

and film-writing system designed to produce images up to 8 by 10 in. in size. The instrument can operate in either of two modes--an input or scanning mode, or an output or writing mode. The writing mode is used to convert CCT values to images in photographic form. For this mode of operation, the instrument is equipped with a rotating drum and an optical system consisting of a light-emitting diode (LED), a selectable aperture, and a lens system that focuses a spot of light from the LED onto the perimeter of the drum. The drum is housed in a light-tight enclosure, which is demountable and is removed to a photographic darkroom for film loading and unloading. A piece of film is clamped to the outside of the drum for exposure.

2. The film can be exposed using 12.5-, 25.0-, or 50.0-μm spots of light from the LED. The raster interval and spot size, which are

selectable, control the size of the negatives that will be produced. As the drum rotates, the carriage supporting the optical system is stepped one step per drum revolution in the axial direction at the selected raster interval until the total area of the film or the area of interest has been exposed. The use of high-speed film permits very short exposure times and results in a recording rate of up to 60,000 exposures (or pixels) per second.

3. The intensity of light from the LED is modulated incrementally in proportion to the values recorded on the magnetic tape. Thus, as the drum of the film reader/writer rotates, a spot is exposed on the film for each pixel value in a scan line (row). When an interrecord gap code occurs, the LED is extinguished until the drum revolution is completed and the carriage for the optical system has moved forward one increment. Exposure of the next row of spots then begins. This process is repeated until the end-of-file code occurs on the magnetic tape.

4. The film reader/writer is controlled by a minicomputer so that real-time manipulation of the CCT values can be used to produce a number of photographic effects. However, for this capability to be used successfully, very careful control over the photographic process and knowledge of the relation between the digital input from the magnetic tape and the photographic output of the film writer are required.

APPENDIX B: INSTRUCTIONS FOR READING MAP COORDINATES

Background

1. Locations can be identified on topographic maps prepared by the U. S. Geological Survey using the following standard coordinate systems:

   a. Universal Transverse Mercator (UTM)

   b. Geographic (latitude and longitude)

   c. Township - Range - Section (TRS)

The UTM coordinate system is used extensively for point location by the military and other Governmental agencies. The reasons it has gained such wide acceptance are due to the ease with which it can be used and the precision inherent in its design. Based completely on the metric system, the UTM system requires no approximation methods to locate a given point on a 1:25,000 scale map to within 10 m in either of the two coordinate directions of the map.

2. Geographic coordinates are historically a navigational set of coordinates. They are used for point location where reckoning over great distances is required (e.g., sea, air, and orbital space travel). The system employs a uniformly consistent network of intersecting orthogonal curved lines that conform naturally to the solid spherical shape of the earth. However, the precision with which a given point on the surface of the earth can be determined depends on its location. For example, at Mobile, Alabama, a point can be located to within ± 27 m in the East-West direction and ± 31 m in the North-South direction (i.e., assuming a ± 1 sec of arc precision).

3. The TRS system is not a point-locating system but rather an area-locating system. Its greatest utility is found in documenting the locations of parcels of land in titles and deeds. The TRS system is convenient for local location of areas, but over great distances that cross many TRS systems, it fails both as a convenient system and as a universally applicable system.

Purpose and Scope

4. The purpose of this appendix is to provide detailed instructions on reading map coordinates (based on Reference 35*) for locating sites requiring administrative action by the Regulatory Functions Branch of the Mobile District.

5. The scope includes instructions for determining site coordinates from the three types of coordinate systems described in paragraph 1. Further, a supplemental discussion on map scales and conversion of UTM to geographic coordinates and geographic to UTM coordinates using a WES-developed computer program is included.

Reading Map Coordinates

6. A description for reading coordinates and extracting their values in each of the three systems listed under scope is discussed in greater detail below. First, however, a brief introduction to a common attribute of all map coordinate systems, topographic map scale, is essential.

Topographic map scale

7. The scale of any map represents a ratio of "actual" map distance to ground distance for a common set of units. That is

$$\text{scale} = \frac{\text{map distance}}{\text{ground distance}}$$

where the units of map and ground distances are the same. As an example, assume that the measured distance between two points on a map is actually 1 in. and that this distance corresponds to 1 mile on the ground.

Then

$$\text{scale} = \frac{1\ \text{inch}}{1\ \text{mile}}$$

* Reference numbers refer to similarly numbered items in the list of references following the main text on page 115.

$$= \frac{1 \text{ in.}}{63{,}360 \text{ in.}}$$

which is expressed as 1 in. to 63,360 in., or more simply 1:63,360. Since this method of expressing map scale is unitless (i.e., does not depend on inches, feet, miles, metres, etc.), it can be written in terms of various units and still be equally applicable. Hence, instead of 1 in. to 63,360 in., one could just as well have expressed the scale as 1 cm to 63,360 cm or 1 ft to 63,360 ft.

8. One aspect of the scale of maps that can become easily confusing is the perceived size of a given area on a map as the scale of the map changes. The size of the area on a map varies directly with the square of the change in map scale. This simply says, for example, that an area of 1 sq in. mapped at a scale of 1:24,000 will shrink to 0.25 sq in. when mapped at a scale of 1:48,000 and will increase to 4 sq in. when mapped at a scale of 1:12,000. Figure B1 graphically illustrates this relationship.

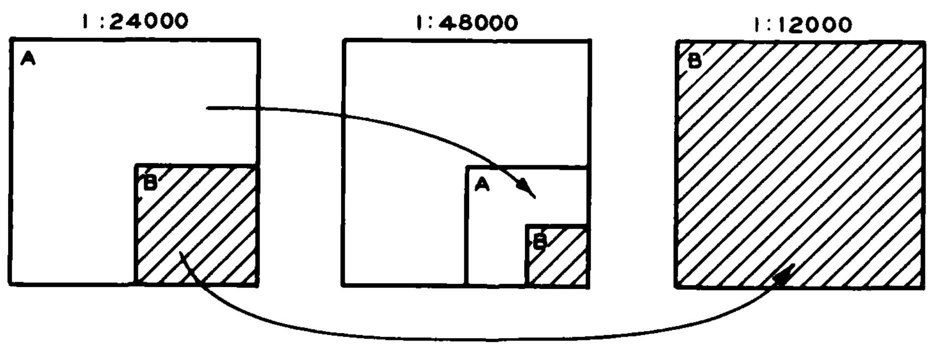


Figure B1. Area shown on a map increases as scale increases and decreases as scale decreases

Universal Transverse Mercator Coordinates

9. The UTM system, while appearing unwieldy at first, offers a very functional system of coordinates. Two facts about this system must be borne in mind if a clear understanding is to be achieved:

a. The world surface is divided into 6-deg units (zones) of which there are 60 total. These zones run from latitude

80°S to latitude 84°N. Each zone has a unique number (Figure B2) assigned and the numbering starts at longitude 180° (the international date line).

b. Each zone is divided horizontally by the equator and vertically by a central meridian.

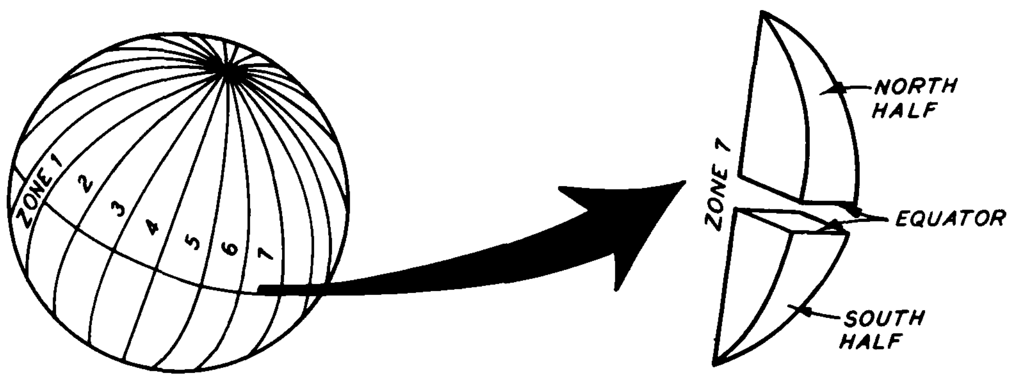


Figure B2. Arrangement of UTM zones on the earth

The above two facts produce a series of surface wedges for the earth, and each wedge has two numbering systems. The equator acts as the dividing line for each wedge; thus, the north and south halves have separate but similar numbering sequences.

10. In a fashion similar to zone, the grid is divided in the N-S direction by a series of lines that are spaced at 8-deg latitude intervals (Figure B3). Counting vertically, the 8-deg units are started in

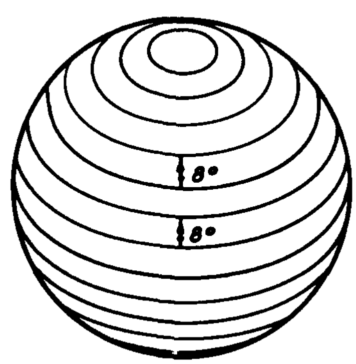


Figure B3. Arrangement of UTM rows on the earth

the south at 80^{0} latitude and in the north at the equator or 0^{0} latitude. Since it is obvious that there will be corresponding 8-deg sections in the north and south halves of each zone, the earth has been labelled with alphabetic characters from C through X (with I and O omitted) for 8-deg rows (Figure B4). A particular area on the earth would be

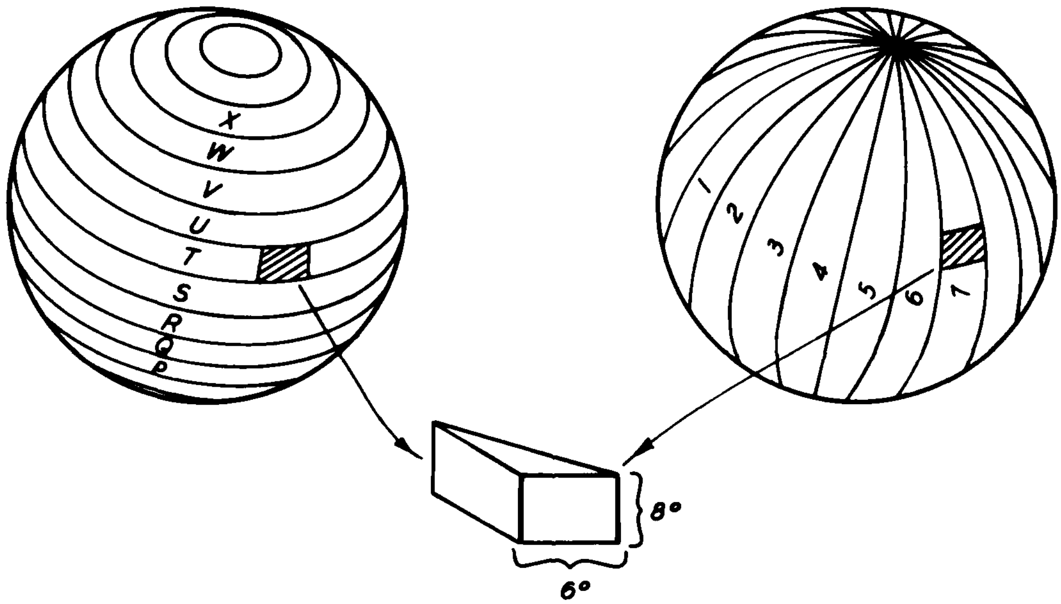


Figure B4. Example of zone 7 row T grid

designated as shown by the 7T grid example in Figure B4. Further subdivisions of the 7T grid and other grids can be made depending on the scale of the map. For example, grids at map scales of 1:24,000 and 1:62,500 are subdivided into grid squares of 1000 m on a side. Given such a map, it is very easy to determine the location of a particular site within any given 1000-m grid square.

11. To facilitate the procedure for determining the UTM coordinates of a given point of interest, a template for UTM coordinates of an appropriate scale (Figure B5) can be used. A procedure for using this template is as follows:

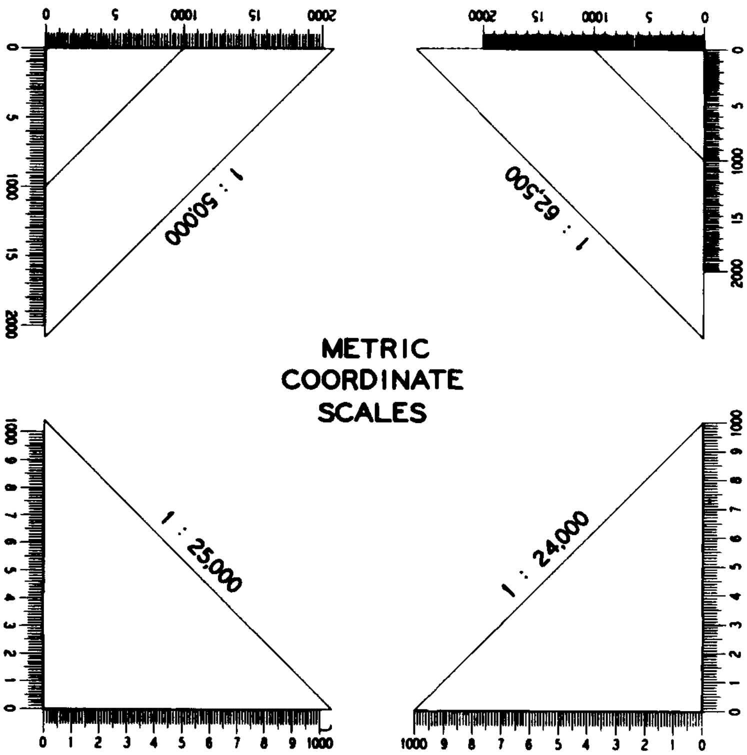


Figure B5. UTM grid coordinate template

a. Choose the appropriate map scale on the UTM template to match that of the map.

b. Rotate the template until the appropriate scale is in the lower right-hand corner of the template.

c. Place the appropriate template scale over the UTM grid square of interest (if the squares are not present, they must be drawn onto the map).

d. Position the zero point of the template over the southeast corner point of the grid square.

e. Align the axis of the template parallel with the sides of the grid square.

f. Slide the template to the west keeping the easting line of the template parallel and touching the south side of the UTM grid square.

g. Continue moving the template to the west until the northing line of the template intersects the point of interest. The template should now be positioned as shown in Figure B6.

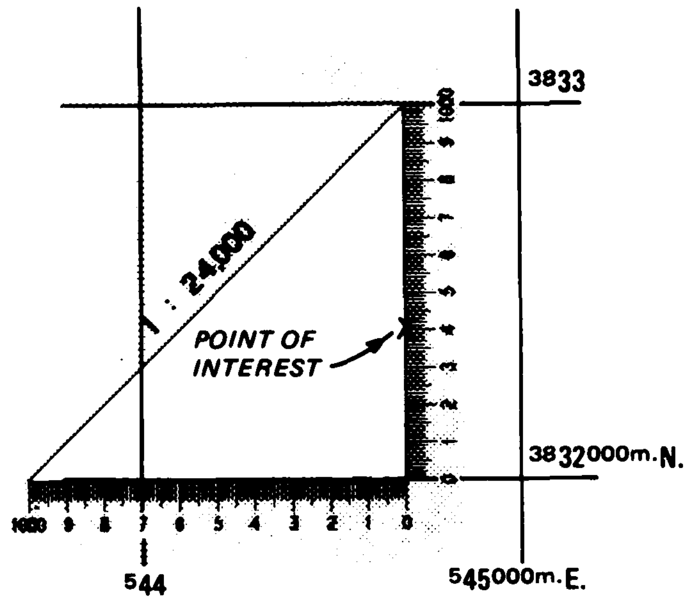


Figure B6. Position of template for determining UTM grid coordinates

h. Determine the easting coordinate of the point of interest.

(1) Read the template at the intersection of the west side of the grid square and the easting line of the template. In Figure B6, this number is 700.

(2) Determine the easting coordinate of the west side of the UTM grid square. In Figure B6, this number is 544000.

(3) Add the two numbers just determined (parts (1) and (2)) to obtain the easting coordinate of the point of interest. In Figure B6, the easting coordinate of the point of interest is 700 + 544000 = 544700.

i. Determine the northing coordinate of the point of interest.

(1) Read the template at the intersection of the point of interest and the northing line of template. In Figure B6, this number is 410.

(2) Determine the northing coordinate of the south side of the UTM grid square. In Figure B6, this number is 3832000.

(3) Add these two numbers to obtain the northing coordinate of the point of interest. In Figure B6, the northing coordinate of the point of interest is 410 + 3832000 = 3832410.

14. Once the easting and northing coordinates have been determined, they are normally expressed together as an ordered pair of numbers. For example, the UTM coordinates of the point of interest in Figure B6, assuming zone 16 and Row R, are expressed as 16R, 544700 E, 3832410 N. This can be somewhat simplified by writing 554700, 3832410 if it is understood that the coordinates are in the northern hemisphere and in zone 16.

Geographic coordinates

15. In the geographic coordinate system, the surface of the earth is divided into units of degrees in both the north-south and east-west directions. Passing from north to south are 360 lines (meridians) that intersect the equator at every 1-deg increment. The meridians allow for reporting over east or west position (longitude) with respect to the Prime Meridian (0°) at Greenwich, England. Passing in the east-west direction are 89 lines (parallels) in the northern hemisphere (likewise in the southern hemisphere) that are parallel to the equator and intersect the meridian at 90-deg angles. Beginning at the equator, and moving northward (or southward) the parallels intersect the meridians at every 1-deg increment. The parallels allow for reporting over north or south position (latitude) with respect to the equator.

16. To simplify the procedure for determining the geographic coordinates of a given map feature or point of interest, a template for geographic coordinates of an appropriate scale* can be used (Figure B7). A procedure for using this template is as follows:

> a. Choose the appropriate map scale on the geographic coordinate template to match that of the map.

---

* A perfectly general Geographic Coordinate template cannot be constructed that can be applied anywhere on the surface of the earth. The reason for this is that the meridian lines close as they approach the poles and a template that remains fixed along its latitudinal axis cannot accommodate this closure. As a consequence, the template provided the Mobile District with this appendix was constructed especially for use between latitudes of 30°N and 35°N. A very close fit ($<\pm 1$ sec) occurs between 32°N and 33°N and an overall precision of ∓ 5 sec between 30°N and 35°N can be expected.

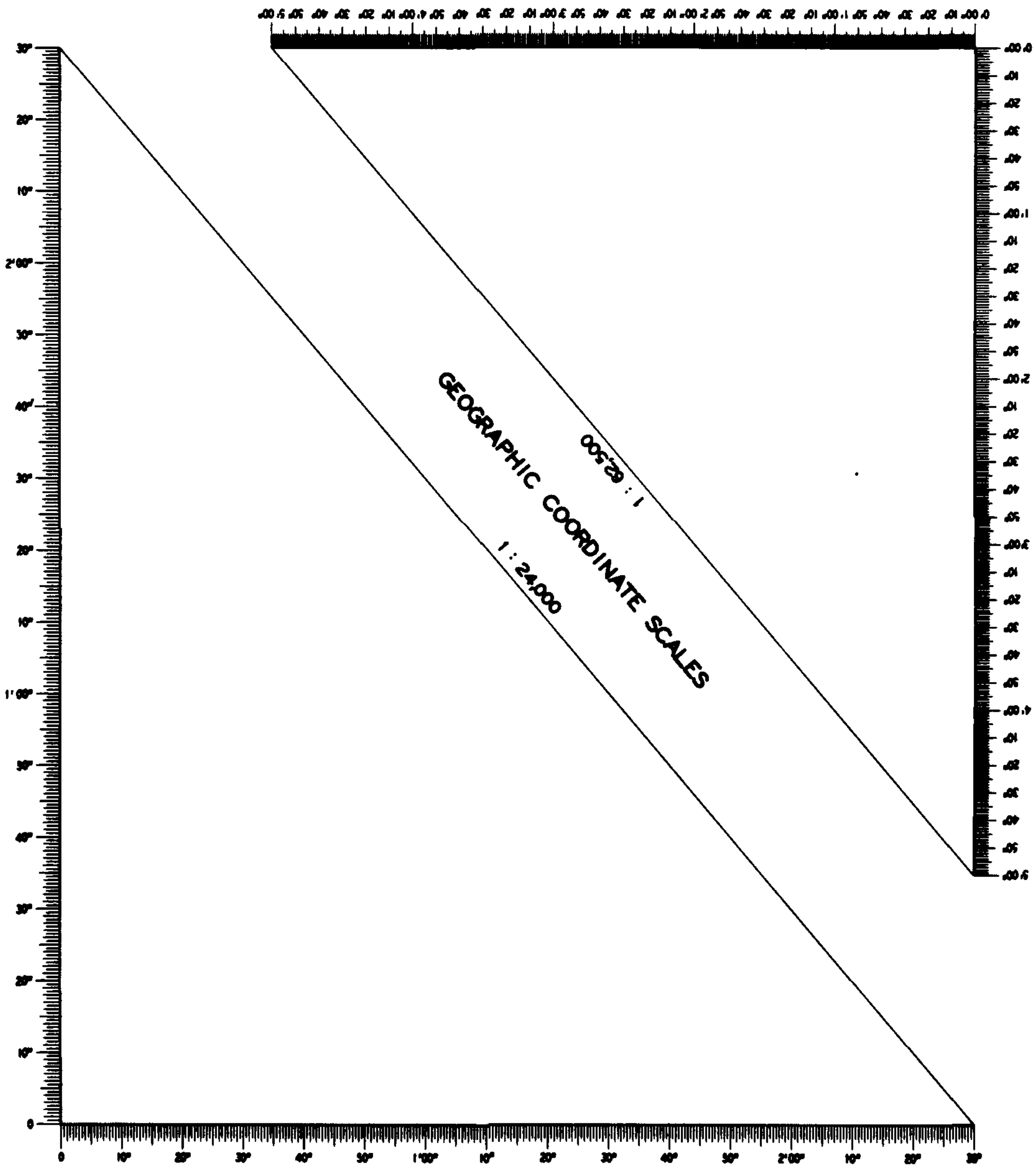


Figure B7. Geographic grid coordinate template

b. Rotate the template until the appropriate scale is in the lower left-hand corner of the template.

c. Place the appropriate template scale over the geographic "grid square" of interest* (if the squares are not present, they must be drawn onto the map).

d. Position the zero point of the template over the south-west corner point of the grid square.

e. Align the axis of the template parallel with the sides of the grid square.

f. Slide the template to the right, keeping the latitudinal line of the template parallel and touching the south line of the grid square.

g. Continue moving the template to the right until the longitudinal line of the template intersects the point of interest. The template should now be positioned as shown in Figure B8.

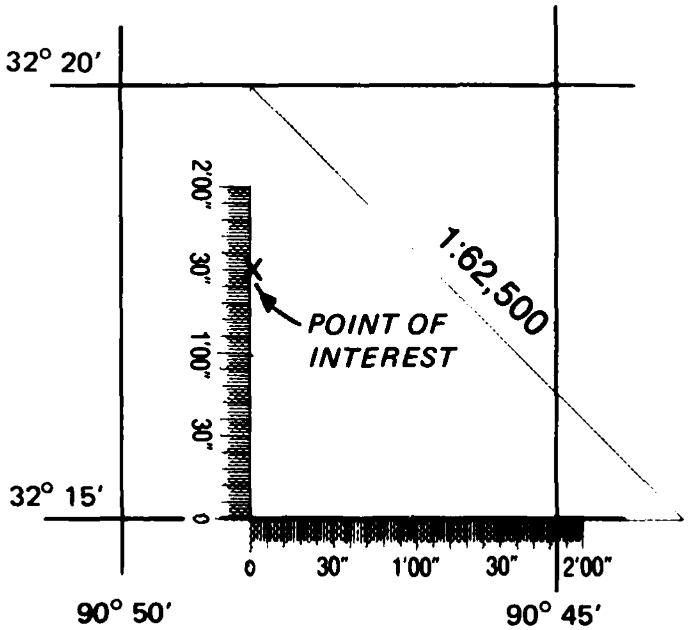


Figure B8. Position of template for determining geographic coordinates

---

[illegible] as they approach the poles, a grid square, [illegible] However, for maps at scales of [illegible] district, the concept of a grid [illegible] most applications.

h. Determine the latitude of the point of interest.

(1) Read the template at the intersection of the longitudinal line of the template and the point of interest. In Figure B8 this number is about 1 min and 30 sec or 1' 30".

(2) Determine the latitude of the south line of the grid square. In Figure B8, this number is 32°15'.

(3) Add the two numbers (parts (1) and (2)) to obtain the latitude of the point of interest. In Figure B8, the sum is 32°16'30".

i. Determine the longitude of the point of interest.

(1) Read the template at the intersection of the right side of the grid square and the latitudinal line of the template. In Figure B8, this number is 01 min and 50 sec or 1'50".

(2) Determine the longitude of the east side of the grid square. In Figure B8, this number is 90°45'.

(3) Add the two numbers (parts (1) and (2)) to obtain the longitude of the point of interest. In Figure B8, the sum is 90°46'50".

17. Once the latitude and longitude have been determined, they are normally expressed together as an ordered pair or numbers. The latitudinal coordinate precedes the longitudinal coordinate. In the preceding example, geographic coordinates of the point of interest (Figure B8) are expressed as 32°16'30" North, 90°46'50" West or more simply 32°16'30" N, 90°46'50" W.

Township - Range -
Section coordinates

18. Throughout most of the U. S., two series of known lines have been established by precise surveying methods. The lines passing N-S are called principal meridians; those passing E-W are called base lines. The intersection of a principal meridian with a base line yields a zero point or origin from which a series of squares (6 miles on a side) are established. To the north or south of an origin, a square is identified by a township number (T, N or S). To the east or west of an origin a square is given a range number (R, E or W) as in Figure B9.

19. A known square (with T and R values identified) is then further divided into 1-square mile units called sections, in a 6 by 6 array, with each section bearing a number as shown in Figure B10.

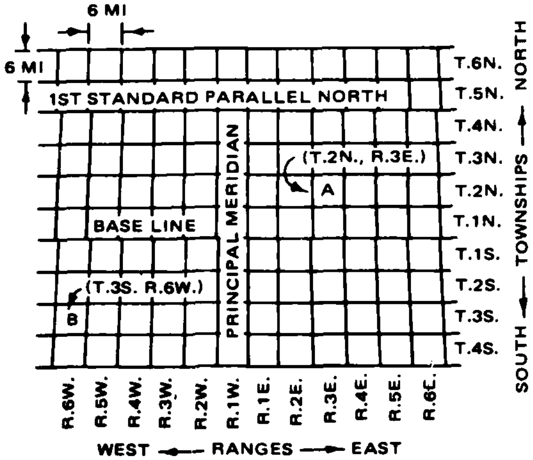


Figure B9. Designation of townships and ranges

R.6W.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

T.2S.

Figure B10. A township divided into 36 1-square mile sections

20. As an example for reporting the position of an area of interest in the TRS system, assume the given area to be the 20-acre parcel of land shown in Figure B11. Also assume that the section is

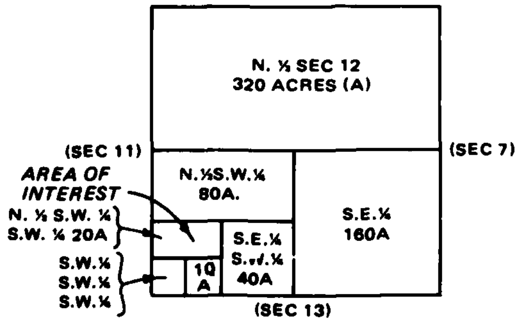


Figure B11. A section subdivided into many units

section 12 of township 2 North, range 3 East (Figure B9). For this parcel of land, the reported position in the TRS system would be expressed as T2N, R3E, S12 (N 1/2 SW 1/4 SW 1/4 20A).

Coordinate conversion

21. In response to the need of the District to rapidly transform UTM to geographic coordinates and geographic to UTM coordinates, a computer program called CONVERT was developed. The program logic was based on information from References 36, 37, and 38. CONVERT was written expressly for UTM Zone 16 since the District lies wholly within this zone.

22. The program (listed in Table B1) begins by asking the user to select one of two types of transformations - either UTM to geographic or geographic to UTM. After the selection is made, the program responds with a series of explanatory statements about the operation of the program. Then a sample input and its corresponding output are given as an example of the type of transformation requested. The program then asks for the values of the coordinates to be transformed. It transforms them and asks again for another set of coordinates. This pattern repeats until the user responds properly to either terminate the program or select the other mode of transformation.

Table B1

Computer Listing of the Program CONVERT

```
10 INTEGER CHOICE,UTMG,GEOU,CHECK,YES,NO
20 DOUBLE PRECISION LONG0
30 COMMON LONG0
40 DATA UTMG/4HUTMG/,GEOU/4HGEOU/
50 DATA YES/3HYES/,NO/1H /
60 LONG0=87.D0
70C
80 1 FORMAT(A4)
90 PRINT,"*************************************************************"
100 PRINT," "
112 PRINT,"                     PROGRAM CONVERT"
120 PRINT," "
130 PRINT,"    CONVERT PROVIDES COORDINATE CONVERSION BETWEEN THE"
140 PRINT,"    UTM AND GEOGRAPHIC COORDINATE SYSTEMS.  CONVERSIONS"
150 PRINT,"    ARE VALID FOR COORDINATES LYING WITHIN UTM ZONE 16."
160 PRINT,"    THE USER WILL FIRST BE ASKED TO MAKE A CHOICE BETWEEN"
170 PRINT,"    CONVERTING FROM UTM TO GEOGRAPHIC COORDINATES (UTMGEO)"
180 PRINT,"    OR FROM GEOGRAPHIC TO UTM COORDINATES (GEOUTM). FROM"
190 PRINT,"    THAT POINT ON, THE USER SIMPLY RESPONDS TO THE QUESTIONS"
200 PRINT,"    AS THEY ARE ASKED BY THE COMPUTER."
210 PRINT," "
220 PRINT,"*************************************************************"
230 10 PRINT," "
240 PRINT,"WHAT IS YOUR CHOICE OF CONVERSION? UTMGEO OR GEOUTM?"
250 PRINT,"RESPOND BY ENTERING EITHER UTMGEO OR GEOUTM AFTER THE"
260 PRINT,"EQUAL SIGN APPEARS AND THEN HIT THE RETURN KEY."
270 PRINT," "
280 20 READ 1,CHOICE
290 CHECK=0
300 IF(CHOICE.EQ.UTMG) CALL UTMGEO(CHECK)
310 IF(CHOICE.EQ.GEOU) CALL GEOUTM(CHECK)
320 IF(CHECK.NE.0) GO TO 30
330 PRINT," "
340 PRINT,"YOU HAVE TYPED IN AN INCORRECT CHOICE. PLEASE"
350 PRINT,"TRY AGAIN. YOUR CHOICES ARE ONLY UTMGEO OR GEOUTM."
360 PRINT," "
370 GO TO 20
380 30 PRINT,"DO YOU WANT TO CHOOSE THE OTHER TYPE OF CONVERSION NOW?"
390 PRINT,"IF YOU DO, PLEASE TYPE YES AFTER THE EQUAL SIGN APPEARS"
400 PRINT,"AND HIT RETURN. IF YOU DO NOT, SIMPLY HIT THE RETURN KEY."
410 PRINT," "
420 READ 1,CHOICE
430 IF(CHOICE.EQ.YES) GO TO 10
```

(Continued)

Table B1 (Continued)

```
PRINT," "
PRINT,"PROGRAM TERMINATED NORMALLY"
PRINT,"GOOD BYE"
STOP
END
SUBROUTINE UTMGEO(CHECK)
INTEGER CHECK
DOUBLE PRECISION LAT,LONG0,LONG,NORTH,EAST,MIN,DEG,SEC,DPR
COMMON LONG0
1 FORMAT(V)
3 FORMAT(2X,27H30  20' 00"      86  25' 00")
CHECK=1
PRINT," "
PRINT,"YOU HAVE CHOSEN TO CONVERT UTM COOR-"
PRINT,"DINATES TO GEOGRAPHIC COORDINATES."
PRINT," "
PRINT,"AFTER THE FIRST EQUAL SIGN APPEARS, ENTER YOUR EASTING"
PRINT,"VALUE AND HIT RETURN. AFTER THE SECOND EQUAL SIGN APPEARS,"
PRINT,"ENTER YOUR NORTHING VALUE AND HIT RETURN. THE EQUIVALENT"
PRINT,"GEOGRAPHIC COORDINATES WILL THEN BE CALCULATED AND PRINTED"
PRINT,"OUT. AN EXAMPLE INPUT AND THE CORRESPONDING OUTPUT IS AS"
PRINT,"FOLLOWS:"
PRINT," "
PRINT,"=588118"
PRINT,"=3355897"
PRINT," "
PRINT,"  LATITUDE        LONGITUDE"
PRINT 3
PRINT," "
PRINT,"THIS PROCEDURE WILL REPEAT UNTIL YOU RESPOND WITH A COMMA"
PRINT,"FOR THE EASTING VALUE AND HIT RETURN. GOOD LUCK."
PRINT," "
PRINT,"-----------------------------------------------------------"
PRINT," "
2 FORMAT(1X,2(I3," ",1X,I2,"'",1X,I2,1H",3X))
DPR=57.29577951D0
10 READ 1,EAST
IF(EAST.LE.0.0D0) GO TO 100
IF(EAST.GE.863621.D0) GO TO 20
GO TO 30
20 PRINT," "
PRINT,"          ***** WARNING *****"
PRINT," "
PRINT,"THIS CHOICE OF EASTING EXCEEDS THE EASTERN-"
PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
PRINT,"COMPUTATION WILL CONTINUE."
PRINT," "
30 CONTINUE
```

(Continued)

```
930 IF(EAST.LE.136380.D0) GO TO 40
940 GO TO 50
950 40 PRINT," "
960 PRINT,"           ***** WARNING *****"
970 PRINT," "
980 PRINT,"THIS CHOICE OF EASTING EXCEEDS THE WESTERN-"
990 PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
1000 PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
1010 PRINT,"COMPUTATION WILL CONTINUE."
1020 PRINT," "
1030 50 CONTINUE
1040 READ 1,NORTH
1050 IF(NORTH.GE.3920893.D0) GO TO 60
1060 GO TO 70
1070 60 PRINT," "
1080 PRINT,"           ***** WARNING *****"
1090 PRINT," "
1100 PRINT,"THIS CHOICE OF NORTHING EXCEEDS THE NORTHERN-"
1110 PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
1120 PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
1130 PRINT,"COMPUTATION WILL CONTINUE."
1140 PRINT," "
1150 70 CONTINUE
1160 IF(NORTH.LE.3269071.D0) GO TO 80
1170 GO TO 90
1180 80 PRINT," "
1190 PRINT,"           ***** WARNING *****"
1200 PRINT," "
1210 PRINT,"THIS CHOICE OF NORTHING EXCEEDS THE SOUTHERN-"
1220 PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
1230 PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
1240 PRINT,"COMPUTATION WILL CONTINUE."
1250 PRINT," "
1260 90 CONTINUE
1270 CALL UTMDEG(EAST,NORTH,LAT,LONG)
1280 LONG1=LONG
1290 LAT=LAT*DPR
1300 NDEG1=LAT
1310 NMIN1=(LAT-NDEG1)*60.D0
1320 NSEC1=((LAT-NDEG1)*60.D0-NMIN1)*60.D0+0.50001
1330 IF(NSEC1.EQ.60) NMIN1=NMIN1+1
1340 IF(NSEC1.EQ.60) NSEC1=0
1350 IF(NMIN1.EQ.60) NDEG1=NDEG1+1
1360 IF(NMIN1.EQ.60) NMIN1=0
1370 NMIN1=100+NMIN1
1380 NSEC1=100+NSEC1
1390 LONG=LONG0+LONG1/3600.D0
1400 IF(EAST.GE.500000.D0) LONG=LONG0-LONG1/3600.D0
1410 NDEG2=LONG
```

(Continued)

```
1420 NMIN2=(LONG-NDEG2)*60.D0
1430 NSEC2=((LONG-NDEG2)*60.D0-NMIN2)*60.D0+0.50001
1440 IF(NSEC2.EQ.60) NMIN2=NMIN2+1
1450 IF(NSEC2.EQ.60) NSEC2=0
1460 IF(NMIN2.EQ.60) NDEG2=NDEG2+1
1470 IF(NMIN2.EQ.60) NMIN2=0
1480 NMIN2=100+NMIN2
1490 NSEC2=100+NSEC2
1500 PRINT," "
1510 PRINT,"  LATITUDE        LONGITUDE"
1520 PRINT 2,NDEG1,NMIN1,NSEC1,NDEG2,NMIN2,NSEC2
1530 PRINT," "
1540 GO TO 10
1550 100 PRINT," "
1560 PRINT,"--------------------------------------------------"
1570 PRINT," "
1580 RETURN
1590 END
1600 SUBROUTINE UTMDEG(EAST,NORTH,LAT,LONG)
1610 IMPLICIT DOUBLE(A-Z)
1620 INTEGER IER
1630 COMMON LONG0
1640 COMMON/ABCDE/A,B,C,D,E,NORTHX
1650 SIN(X)=DSIN(X)
1660 COS(X)=DCOS(X)
1670 SQRT(X)=DSQRT(X)
1680 ABS(X)=DABS(X)
1690 1 FORMAT(V)
1700 SA=6378206.4D0
1710 SB=6356583.8D0
1720 K0=0.9996D0
1730 NORTHX=NORTH
1740C
1750 E2=1.D0-(SB/SA)**2
1760 EP2=(SA/SB)**2-1.D0
1770 N=(SA-SB)/(SA+SB)
1780 N2=N**2
1790 N3=N**3
1800 N4=N**4
1810 N5=N**5
1820C
1830 EASTP=500000.D0-EAST
1840 IF(500000.D0.LE.EAST) EASTP=EAST-500000.D0
1850 Q=0.000001D0*EASTP
1860 Q2=Q**2
1870C
1880 A=SA*(1.D0-N+(5.D0/4.D0)*(N2-N3)+(81.D0/64.D0)*(N4-N5))
1890 B=1.5D0*SA*(N-N2+(7.D0/8.D0)*(N3-N4)+(55.D0/64.D0)*N5)
1900 C=(15.D0/16.D0)*SA*(N2-N3+0.75D0*(N4-N5))
```

(Continued)

Table B1 (Continued)

```
D=(35.D0/48.D0)*SA*(N3-N4+(11.D0/16.D0)*N5)
E=(315.D0/51.D0)*SA*(N4-N5)
C
PHIEST=NORTH/(A*K0)
CALL INTERP(PHI,PHIEST,FUNC,1.0E-12,100,IER)
C
SINPHI=SIN(PHI)
COSPHI=COS(PHI)
TANPHI=SINPHI/COSPHI
ONESEC=(1.D0/3600.D0)*0.0174532925D0
SINONE=SIN(ONESEC)
C
X=1.D0-E2*(SINPHI**2)
RHO=SA*(1.D0-E2)/(X*SQRT(X))
NU=SA/SQRT(X)
F=NU*K0*1.D-06
C
VII=(1.D0/(2.D0*(F**2)*SINONE))*TANPHI*
&    (1.D0+EP2*(COSPHI**2))
C
VIII=(1.D0/(24.D0*(F**4)*SINONE))*TANPHI*
&     (5.D0+3.D0*(TANPHI**2)+6.D0*EP2*(COSPHI**2)-
&     6.D0*(EP2*SINPHI**2)-3.D0*(EP2**2)*(COSPHI**4)-
&     9.D0*(EP2**2)*(COSPHI**2)*(SINPHI**2))
C
D6=(1.D0/(720.D0*(F**6)*SINONE))*(Q**6)*TANPHI*
&   (61.D0+90.D0*(TANPHI**2)+45.D0*(TANPHI**4)+
&    107.D0*EP2*(COSPHI**2)-162.D0*EP2*(SINPHI**2)-
&   45.D0*EP2*(TANPHI**2)*(SINPHI**2))
C
IX=1.D6/(NU*SINONE*COSPHI*K0)
C
X=(1.D0/(6.D0*(F**3)*SINONE*COSPHI))*(1.D0+2.D0*
&  (TANPHI**2)+EP2*(COSPHI**2))
C
E5=(1.D0/(120.D0*(F**5)*SINONE*COSPHI))*(Q**5)*
&   (5.D0+28.D0*(TANPHI**2)+24.D0*(TANPHI**4)+6.D0*
&    EP2*(COSPHI**2)+8.D0*EP2*(SINPHI**2))
C
DELPHI=((Q2*(VII-VIII*Q2)+D6)/3600.D0)*0.0174532925D0
LAT=PHI-DELPHI
LONG=Q*(IX-X*Q2)+E5
C
RETURN
END
SUBROUTINE INTERP(X,XST,F,EPS,IEND,IER)
C
DOUBLE PRECISION X,F,DERF,XST,TOL,TOLF,DX,A
C
```

Table B1 (Continued)

```
C    PREPARE ITERATION
C
 IER=0
 X=XST
 TOL=X
 CALL FCT(TOL,F,DERF)
 TOLF=100.0*EPS
C
C
C    START ITERATION LOOP
C
 DO 6 I=1,IEND
 IF(F)1,7,1
C
C    EQUATION IS NOT SATISFIED BY X
C
 1 IF(DERF)2,8,2
C
C    ITERATION IS POSSIBLE
C
 2 DX=F/DERF
 X=X-DX
 TOL=X
 CALL FCT(TOL,F,DERF)
C
C     TEST ON SATISFACTORY ACCURACY
C
 TOL=EPS
 A=DABS(X)
 IF(A-1.D0)4,4,3
 3 TOL=TOL*A
 4 IF(DABS(DX)-TOL)5,5,6
 5 IF(DABS(F)-TOLF)7,7,6
 6 CONTINUE
C
C      END OF ITERATION LOOP
C
C
C      NO CONVERGENCE AFTER IEND ITERATION STEPS. ERROR RETURN.
C
 IER=1
 7 RETURN
C
C      ERROR RETURN IN CASE OF ZERO DIVISOR
C
 8 IER=2
 RETURN
 END
 SUBROUTINE FCT(X,F,DERF)
```

(Continued)

```
IMPLICIT DOUBLE(A-Z)
COMMON/ABCDE/A,B,C,D,E,NORTH
SIN(X)=DSIN(X)
COS(X)=DCOS(X)
K0=0.9996D0
F=(A*X-B*SIN(2.D0*X)+C*SIN(4.D0*X)-
&  D*SIN(6.D0*X)+E*SIN(8.D0*X))*K0-NORTH
C
DERF=(A-2.D0*B*COS(2.D0*X)+4.D0*C*COS(4.D0*X)-
&      6.D0*D*COS(6.D0*X)+8.D0*E*COS(8.D0*X))*K0
C
RETURN
END
SUBROUTINE GEOUTM(CHECK)
INTEGER CHECK,IEAST,INORTH
DOUBLE PRECISION LAT,LONG0,LONG,NORTH,EAST,MIN,DEG,SEC,K0
COMMON LONG0
1 FORMAT(V)
2 FORMAT(1X,I7,6X,I8)
CHECK=1
PRINT," "
PRINT,"YOU HAVE CHOSEN TO CONVERT GEOGRAPHIC"
PRINT,"COORDINATES TO UTM COORDINATES."
PRINT," "
PRINT,"AFTER THE FIRST EQUAL SIGN APPEARS, ENTER YOUR VALUE FOR"
PRINT,"LATITUDE (DEG,MIN,SEC) AND HIT RETURN. AFTER THE SECOND EQUAL"
PRINT,"SIGN APPEARS, ENTER YOUR VALUE FOR LONGITUDE (DEG,MIN,SEC)"
PRINT,"AND HIT RETURN. THE EQUIVALENT UTM COORDINATES WILL THEN BE"
PRINT,"CALCULATED AND PRINTED OUT. AN EXAMPLE INPUT AND THE CORRE-"
PRINT,"SPONDING OUTPUT IS AS FOLLOWS:"
PRINT," "
PRINT,"=30,20,00"
PRINT,"=86,05,00"
PRINT," "
PRINT,"EASTING     NORTHING"
PRINT," 538118      3355897"
PRINT," "
PRINT,"THIS PROCEDURE WILL REPEAT UNTIL YOU RESPOND WITH TWO COMMAS"
PRINT,"FOR THE LATITUDE VALUE AND HIT RETURN.  GOOD LUCK."
PRINT," "
PRINT,"-------------------------------------------------------------"
PRINT," "
PRINT," "
10 READ 1,DEG,MIN,SEC
LAT=DEG+MIN/60.D0+SEC/3600.D0
IF(LAT.LE.0.0D0) GO TO 100
IF(LAT.LE.29.5D0) GO TO 20
GO TO 30
```

(Continued)

Table B1 (Continued)

```
20 PRINT," "
PRINT,"             ***** WARNING *****"
PRINT," "
PRINT,"THIS CHOICE OF LATITUDE EXCEEDS THE SOUTHERN-"
PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
PRINT,"COMPUTATION WILL CONTINUE."
PRINT," "
30 CONTINUE
IF(LAT.GE.35.375D0) GO TO 40
GO TO 50
40 PRINT," "
PRINT,"             ***** WARNING *****"
PRINT," "
PRINT,"THIS CHOICE OF LATITUDE EXCEEDS THE NORTHERN-"
PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
PRINT,"COMPUTATION WILL CONTINUE."
PRINT," "
50 CONTINUE
READ 1,DEG,MIN,SEC
LONG=DEG+MIN/60.D0+SEC/3600.D0
IF(LONG.LE.83.25D0) GO TO 60
GO TO 70
60 PRINT," "
PRINT,"             ***** WARNING *****"
PRINT," "
PRINT,"THIS CHOICE OF LONGITUDE EXCEEDS THE EASTERN-"
PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
PRINT,"COMPUTATION WILL CONTINUE."
PRINT," "
70 CONTINUE
IF(LONG.GE.90.75D0) GO TO 80
GO TO 90
80 PRINT," "
PRINT,"             ***** WARNING *****"
PRINT," "
PRINT,"THIS CHOICE OF LONGITUDE EXCEEDS THE WESTERN-"
PRINT,"MOST BOUNDARY OF THE MOBILE DISTRICT. IT WILL"
PRINT,"BE ACCEPTED AS A VALID ENTRY, HOWEVER, AND"
PRINT,"COMPUTATION WILL CONTINUE."
PRINT," "
90 CONTINUE
LONG1=LONG
CALL DEGUTM(LAT,LONG,NORTH,EAST)
PRINT," "
IF(LONG0.LE.LONG1) EAST=-EAST
EAST=500000.D0+EAST
```

(Continued)

Table B1 (Continued)

```
3860 PRINT,"EASTING      NORTHING"
3870 IEAST=EAST+1.D0
3880 INORTH=NORTH+1.D0
3890 PRINT 2,IEAST,INORTH
3900 PRINT," "
3910 GO TO 10
3920 100 PRINT," "
3930 PRINT,"----------------------------------------------------------"
3940 PRINT," "
3950 RETURN
3960 END
3970 SUBROUTINE DEGUTM(LAT,LONG,NORTH,EAST)
3980 IMPLICIT DOUBLE(A-Z)
3990 COMMON LONG0
4000 SIN(X)=DSIN(X)
4010 COS(X)=DCOS(X)
4020 SQRT(X)=DSQRT(X)
4030 ABS(X)=DABS(X)
4040 1 FORMAT(V)
4050 SA=6378206.4D0
4060 SB=6356583.8D0
4070 K0=0.9996D0
4080 DELTA=ABS(LONG0-LONG)*3600.D0
4090 P=0.0001D0*DELTA
4100 LAT=0.0174532925D0*LAT
4110 LONG=0.0174532925D0*LONG
4120C
4130 SINPHI=SIN(LAT)
4140 COSPHI=COS(LAT)
4150 TANPHI=SINPHI/COSPHI
4160 ONESEC=(1.D0/3600.D0)*0.0174532925D0
4170 SINONE=10000.D0*SIN(ONESEC)
4180C
4190 E2=1.D0-(SB/SA)**2
4200 EP2=(SA/SB)**2-1.D0
4210C
4220 N=(SA-SB)/(SA+SB)
4230C
4240 X=1.D0-E2*(SINPHI**2)
4250 RHO=SA*(1.D0-E2)/(X*SQRT(X))
4260 NU=SA/SQRT(X)
4270C
4280 N2=N**2
4290 N3=N**3
4300 N4=N**4
4310 N5=N**5
4320 A=SA*(1.D0-N+(5.D0/4.D0)*(N2-N3)+(81.D0/64.D0)*(N4-N5))
4330 B=1.5D0*SA*(N-N2+(7.D0/8.D0)*(N3-N4)+(55.D0/64.D0)*N5)
4340 C=(15.D0/16.D0)*SA*(N2-N3+0.75D0*(N4-N5))
```

(Continued)

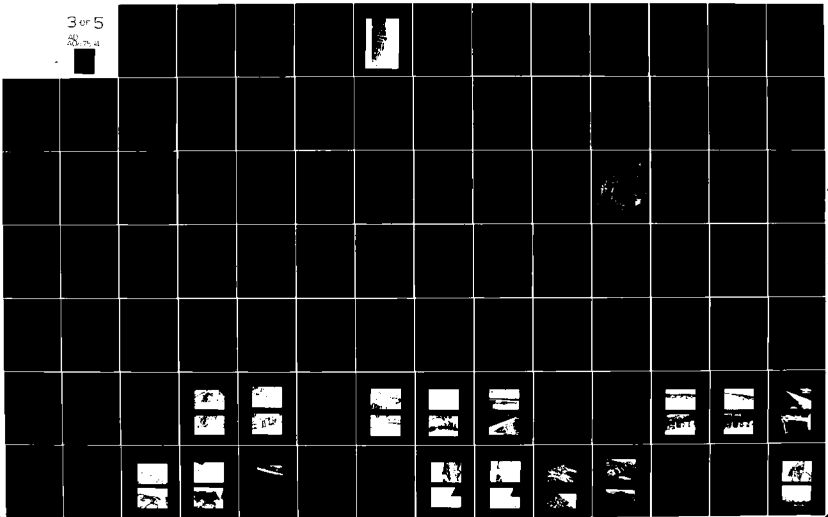
Table B1 (Concluded)

```
 D=(35.D0/48.D0)*SA*(N3-N4+(11.D0/16.D0)*N5)
 E=(315.D0/51.D0)*SA*(N4-N5)
C
 S=A*LAT-B*SIN(2.D0*LAT)+C*SIN(4.D0*LAT)-
&  D*SIN(6.D0*LAT)+E*SIN(8.D0*LAT)
C
 I=S*K0
 II=0.5D0*NU*SINPHI*COSPHI*K0*(SINONE**2)
 III=(1.D0/24.D0)*(SINONE**4)*NU*SINPHI*(COSPHI**3)*
&    (5.D0-(TANPHI**2)+9.D0*EP2*(COSPHI**2)+
&    4.D0*(EP2**2)*(COSPHI**4))*K0
 A6=(1.D0/720.D0)*(P**6)*(SINONE**6)*NU*SINPHI*
&   (COSPHI**5)*(61.D0-58.D0*(TANPHI**2)+(TANPHI**4)+
&   270.D0*EP2*(COSPHI**2)-330.D0*EP2*(SINPHI**2))*K0
C
 IV=NU*COSPHI*SINONE*K0
 V=(1.D0/6.D0)*(SINONE**3)*NU*(COSPHI**3)*
&  (1.D0-(TANPHI**2)+EP2*(COSPHI**2))*K0
 B5=(1.D0/120.D0)*(P**5)*(SINONE**5)*NU*
&    (COSPHI**5)*(5.D0-18.D0*(TANPHI**2)+
&    (TANPHI**4)+14.D0*EP2*(COSPHI**2)-
&    58.D0*EP2*(SINPHI**2))*K0
C
 EAST=IV*P+V*(P**3)+B5
 NORTH=I+II*(P**2)+III*(P**4)+A6
CPRINT 1,EAST,NORTH
 RETURN
 END

READY

*
```

AD-A087 584 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 14/5
REMOTE-SENSING PROCEDURES FOR DETECTING AND MONITORING VARIOUS --ETC
APR 80 H STRUVE, W L KIRK

UNCLASSIFIED WES/TR/EL-80-1 NL

3 of 5
AD A087584



APPENDIX C: DEVELOPMENT OF THE FILM-FILTER MATRICES

1. The study to determine the most frequently occurring activities discussed under the objective and scope of this report revealed that approximately 70 percent of the work load of the Mobile District during a normal year consisted of activities usually occurring along the coastal regions of the District. In pursuit of a typical region of the coast from which spectral data could be obtained, the WES determined that the area along the coast shown in Figure 2 of the main text contained a distribution of activities similar to the normal work load of the District. Thus, this area was determined to be ideal for obtaining remotely sensed data for this study. A flight line along which the MMS could be flown was drawn between the extremes of this region as shown in Figure 2. The NASA JSC, located in Houston, Texas, was asked to fly this line and acquire simultaneously both MMS data and color infrared photography at altitudes of 12,000, 7,000, 4,000, and 2,000 ft.

2. The MMS data obtained served two purposes. One purpose was to investigate the feasibility and practicality of using this type of data for detecting and monitoring regulated activities on a routine basis. The other purpose was to acquire spectral data of the regulated activities for use in the PSSM (see Part III) in developing the film-filter matrices. The discussion of the first of these purposes is presented in Part II of this report. The second purpose is developed in this appendix.

3. The film-filter matrices are arrays of numbers that indicate the suitability of a particular film and filter combination to detect a given feature against a given background. The numbers are the optical density contrast values for a given film-filter combination and feature-background combination. A contrast value can be thought of simply as an index number that indicates the detectability of a given feature against a given background. The greater the index number, the more suitable a given film-filter combination becomes for detecting a given feature-background combination. For the human eye, a threshold value of 0.2 has

been determined as the smallest detectable contrast value. That is, below an index number of 0.2, a feature is not distinguishable from its background and above the value of 0.2 the feature becomes more and more distinguishable with increasing index values.

4. As discussed in Part IV, the PSSM requires as input the reflectance signature of both a feature and its background. The source of data from which the reflectance signatures were derived was the magnetic MMS tapes recorded by JSC during the flight. Over 100 computer-compatible tapes were required to record all the scanner data. However, since the smallest possible resolution element was desired, only the 2,000-ft scanner data were used for extraction of signatures.

5. The procedure for extracting signatures from the data tapes involved the use of four computer programs developed by the WES for this purpose. The diagram shown in Figure C1 depicts the flow of information from a data tape to a final image.

6. The process begins with the program COPY11, which simply copies the original NASA data onto another reel of magnetic tape. This step was necessary since it was found that numerous parity errors were erroneously detected when the NASA tapes were read directly by the following program READ11. No actual errors existed on the original data tapes as far as the authors could determine. For some unknown reason, the tapes were intermittently incompatible with the tape drives at the WES. This problem was solved by simply copying the NASA data tapes onto new reels of tape. The Honeywell tape drives could then read the copied tapes correctly.

7. The next step in the processing sequence was to separate the ancillary data from the image data and write a reformatted data tape. READ11 performed this function. The ancillary data were printed out on the high-speed printer while the image data were being written on tape. The output tape from READ11 contained all eleven bands of the MMS.

8. To separate out a single band of image data for printing images, the program ONEOF11 was executed. The output tape from this step could then be processed by the Optronics film writer to produce an image. An example image resulting from this process is shown in

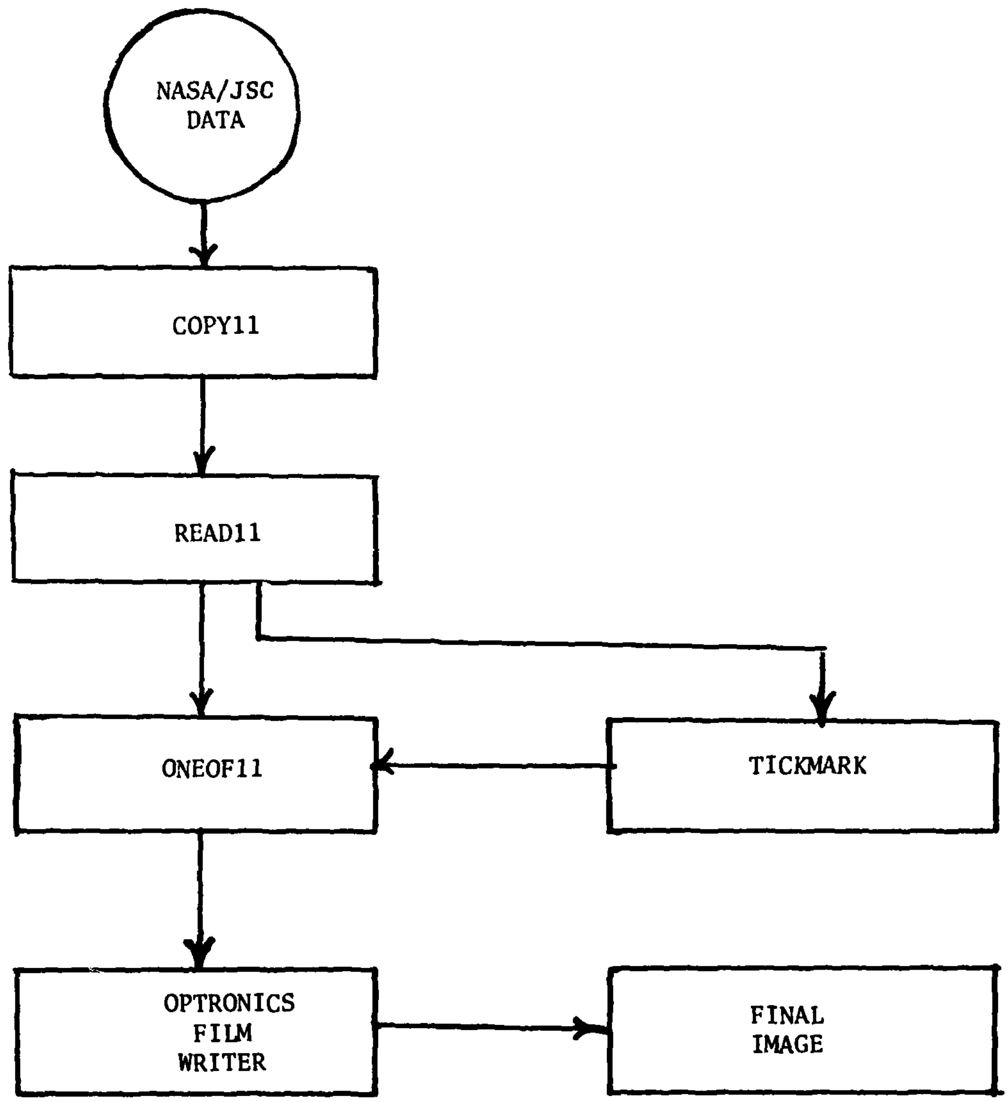


Figure C1. Flow diagram for processing MMS data from NASA data tapes to final image

Figure C2. Note that no image corrections have been performed on the image to remove distortions.

9. Once an image had been produced, it was possible to determine the coordinates of various features and backgrounds from which a reflectance signature could be extracted. By specifying the spatial coordinates of a feature or background, another program, TICKMARK, could be run to actually extract the data. The diagram in Figure C1 shows the position of TICKMARK within the flow diagram. TICKMARK can be given up to 20 sets of location coordinates at any one time. It then can produce an output on the high-speed printer of the spectral values at and surrounding the selected locations. In Table C1 is shown a sample output from TICKMARK for a 9 by 9 array around the pixel number 409 on scan line 790. Each of the eleven bands has an extracted 9 by 9 array printed out. In addition, a summary for these eleven channels (Table C2) is printed out showing the average of the entire array and its standard deviation for each band.

10. TICKMARK also generates a new image data tape containing tickmarks (+ signs) at each of the specified coordinate locations. In this way, one can be certain that the output spectral data have come from the correct location. Examples of the TICKMARKS are shown in Figure C2.

11. The rationale for selecting data sites from which reflectance signatures would be derived was based primarily on the idea that only certain activities and terrain types were of potential interest to the Regulatory Functions Branch of the Mobile District. Signatures from a total of 310 data sites were extracted from within the imagery and grouped into 9 categories. The categories were water, sand, clay, grass, marsh, prairie, forest, and structures. Inspection of the reflectance signatures contained in the water, forest, and structures categories revealed a wide variety of values. This indicated a mixture of features or backgrounds in each of these three categories. Since a reflectance signature attributable to a single feature was desired, it was necessary to subdivide the three categories further.

12. The water, forest, and structure categories were each

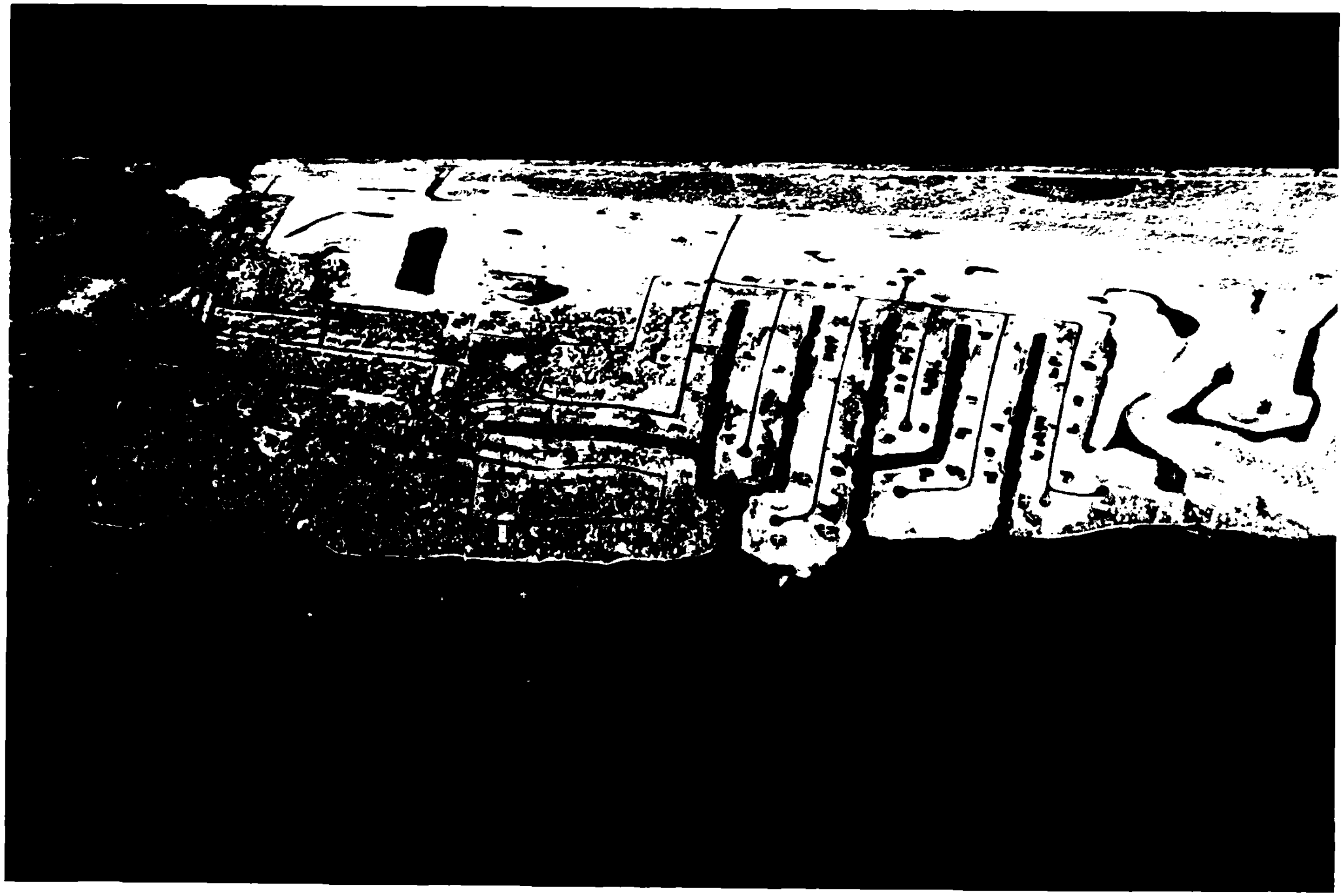


Figure C2. Image produced on the Optronics film writer from the output of the program ONEOF11. Tickmarks (+ signs) were placed in the data arrays before printing by the program TICKMARK

subjected to a clustering procedure developed by the WES.[2]* The procedure looks at each of the signatures of a given category and subdivides them according to spectral similarities. Those signatures that are the closest spectrally are grouped into small clusters or subcategories. The results of this subgrouping were to further divide water into 3 classes, forest into 2 classes, and structures into 4 classes. This gave a total of 14 classes from which feature and background signatures could be drawn. Each of the 14 classes are defined as follows:

Spectral Class	Description
Water 1	Water less than 0.5 yd deep covering white sandy ocean floor
Water 2	Water greater than 0.5 yd and less than 1.0 yd covering white sandy ocean floor
Water 3	Water greater than 1.0 yd deep
Sand	White silica beach sand
Clay	Red clay used frequently as road surfacing material on sandy dirt roads
Grass	Bermuda or St. Augustine grasses usually appearing as domestic lawns or on golf greens
Marsh	Dominant plant forms are salt-grass (*Distichlis spicata*), cord-grass (*Spartina cynosuroides*), bunch switch grass (*Spartina bakeri*), or black-rush (*Juncus roemerianus*)
Prairie	Dominated by the wire-grass (*Aristida stricta*) and other species of *Aristida* with the saw-palmetto (*Serenoa repens*), and many other low shrubs
Forest 1	Mixed forest where dominant trees are loblolly pines (*Pinus taeda*), shortleaf pine (*Pinus echinata*), ironwood (*Cliftonia monoplylla*), and a number of kinds of oak trees
Forest 2	Mixed forest same as Forest 1, except trees are dead or dying
Wooden structures	Piers, docks, boathouses, etc., principally constructed of wood

(Continued)

* Reference numbers refer to similarly numbered items in the list of references following the main text on page 115.

Spectral Class	Description
Concrete structures	Bulkheads, boat ramps, revetments, etc., principally constructed of concrete
Metal structures	Boathouses, hoists, marinas, etc., principally constructed of sheet metal
Asphalt structures	Highways, parking lots, revetments, etc., principally constructed of asphalt

13. Since the PSSM requires reflectance data in percent reflectance and not radiance values as are contained on the MMS magnetic tapes, it was necessary to determine percent reflectance for each of the 14 classes. Conceptually, the most straightforward approach for determining the percent reflectance is to perform ground measurements at the time of overflight of the incident solar light intensity, $I(\lambda)$, and the reflected light intensity, $R(\lambda)$, associated with each class. A simple ratio of these two numbers multiplied by 100 percent gives the percent reflectance, $\rho(\lambda)$, (i.e., $\rho(\lambda) = (R(\lambda)/I(\lambda))$ 100 percent). Ground measurements of this type are, however, very difficult to obtain. Aside from the fact that simultaneous measurements of all the classes at flight time is a monumental task, it is hard to find sample sites of each class that faithfully preserve the same reflectance characteristics at ground level as those measured from the integrated view of an airborne platform. The one exception to this in the present study, however, was the homogeneous white beach sand that occurred frequently along the flight path. Measurements of this material could reliably and consistently be made at ground level with acceptable accuracy. The procedure by which the percent reflectance of the sand was measured employed the use of an ISCO Model SR Spectroradiometer and a Kodak 90 percent Lambertian reflectance "gray" card. This type of reflecting surface reflects 90 percent of the incident light that strikes it. To determine percent reflectance of the sand required first a measurement of the light reflected by the sand and also the light reflected by the gray card. Both the sand and gray card were in a horizontal position when measured. The ratio of the reflected light from sand to that of the gray card times 90 percent gives the percent reflectance of the

beach sand. The results of these measurements are as follows:

λ, mμ	Gray Card*	Sand*	Percent Reflectance
400	1.50	0.60	36
450	10.65	5.10	43
500	13.35	7.05	48
550	14.55	8.40	52
600	20.25	12.60	56
650	19.95	12.75	58
700	17.40	11.40	59
750	15.60	10.50	61
800	10.30	6.85	60
850	9.10	6.15	61
900	7.00	5.00	64
950	4.60	3.50	68
1000	6.10	4.40	65
1050	6.40	4.60	65
1100	5.50	3.95	65

* Units are μw cm^{-2} $m\mu^{-1}$ (microwatts per square centimeter per millimicron).

14. Due to the inherent difficulties mentioned above in making ground measurements of reflectance values, a normalization method was used to calculate reflectance values for the 13 other spectral classes. This method utilized the radiance values recorded by the MMS. These values can be represented by the equation:

$$R_f(\lambda) = c(\lambda)I(\lambda)\rho_f(\lambda)$$

where

$R_f(\lambda)$ = radiance value of the feature f at the MMS in CCT units

$c(\lambda)$ = atmospheric attenuation factor in percent

$I(\lambda)$ = incident solar light intensity in CCT units

$\rho_f(\lambda)$ = reflectance value of the feature f in percent

This relationship is true, of course, for the beach sand so that $R_s = cI\rho_s$ for sand too. Note that the explicit dependence on wavelength has been dropped for simplicity's sake. A ratio can now be formed between R_f and R_s such that:

$$\frac{R_f}{R_s} = \frac{\rho_f}{\rho_s}$$

or

$$\rho_f = \frac{R_f}{R_s} \rho_s$$

Since the values for R_f and R_s are contained on the MMS data tapes and the values of ρ_s are known from ground measurements, this equation is a general expression of the percent reflectance of the other 13 classes. This equation was used to calculate the percent reflectance of the other classes for the first 10 bands of the MMS. The results for all classes are presented in Table C3. The eleventh band (i.e., the thermal band) was not included as part of the reflectance signatures of the features and backgrounds since the PSSM was used to evaluate only film-filter combinations sensitive to the visible and near infrared wavelengths of light.

15. In addition to the spectral reflectance values for features and background, the PSSM requires as input the solar zenith angle, flight altitude, and atmospheric haze condition. All these parameters can be adjusted to suit the conditions of a particular mission. However, in order to reduce the number of possible combinations of parameters, a single nominal (nominal for the Mobile District) value was selected for each. Since most photography is flown during optimum atmospheric conditions, a condition of no haze (i.e. clear) was chosen for the atmospheric parameter. The solar zenith angle was set equal to 30 deg, and the flight altitude to 10,000 ft.

16. To present the contrast index values for all likely combinations of features and backgrounds, a matrix was generated for each film and filter combination used in the PSSM. Each row and column of matrix corresponds to a feature and a background, respectively. The features and background signatures used in the matrices were selected from Table C3. Only those signatures most likely to occur as features were

selected as features, and only those signatures most likely to occur as backgrounds were chosen as backgrounds. The film types used in the PSSM were as follows:

Film No.	Film Description
2402	Kodak Plus-X aerographic (B&W)
2403	Kodak Tri-X Panchromatic (B&W)
2448	Kodak Ektochrome MS Aerographic (Color)
2443	Kodak Aerochrome Infrared (Color)
2424	Kodak Infrared Aerographic (B&W)

The most commonly used filters in aerial photography and those included in the model are the Wratten Nos. 12, 47B, 58, 25A, 87C, and 89B. The final matrices are presented in Tables C4-C20.

17. The matrices are intended to be used for planning purposes. For example, if a flight to be planned required the detection of wooden structures against a background of shallow water less than 0.5 yd deep, one would find the intersection of the row labeled "Wooden Structure" and column labeled "Water 1" in each of the 17 matrices. The object of this search would be to find the film-filter combination that gives a maximum value. This combination would be the optimum film and filter for detecting this feature-background combination.

Table C1

Sample Output from the Program TICKMARK

DATA FOR THE 9 BY 9 ARRAY AROUND SCAN LINE 790 AND PIXEL 409

CHANNEL 1

37	40	40	36	37	35	38	42	29
12	38	41	33	31	36	38	40	37
38	43	37	46	44	54	55	39	37
41	38	45	42	68	124	103	32	33
41	35	43	65	122	118	120	106	32
57	60	86	137	134	118	121	129	102
42	69	78	118	129	116	125	122	125
47	42	70	80	108	125	124	110	126
41	39	36	55	71	110	116	111	58

AVE = 69.2

SD = 36.7

CHANNEL 2

36	38	39	35	35	34	36	32	34
38	39	38	36	33	33	38	33	32
39	39	38	36	35	50	52	32	32
38	39	36	38	63	113	96	41	29
39	36	37	62	110	110	103	99	43
57	57	74	117	113	106	112	114	96
41	62	71	97	115	111	109	114	114
43	44	60	70	95	112	108	104	107
42	41	39	51	65	90	109	100	60

AVE = 63.5

SD = 31.6

CHANNEL 3

38	38	37	35	34	34	33	33	33
38	39	36	33	33	34	34	33	33
39	38	36	34	42	43	32	33	33
38	37	35	48	72	65	38	31	33
36	37	47	71	70	69	67	39	31
46	54	75	73	71	73	72	66	39
48	52	65	73	71	71	73	73	67
41	48	52	63	71	71	68	70	51
40	37	42	49	61	71	67	47	34

AVE = 49.0

SD = 15.6

CHANNEL 4

31	31	29	28	25	25	24	24	24
31	31	28	25	25	25	25	24	25
32	30	28	25	31	31	23	25	25
30	28	27	35	51	47	27	23	25
28	28	35	51	50	48	48	28	22
34	40	54	52	49	51	52	47	28
36	38	46	52	51	50	51	52	47
32	36	39	45	51	50	48	50	36
32	29	30	36	44	51	48	33	25

AVE = 35.9

SD = 10.5

CHANNEL 5

35	35	34	32	30	30	29	30	29
36	35	33	30	29	30	30	30	30
36	35	32	30	34	35	28	30	30
35	33	31	38	51	47	31	28	30
32	32	38	51	49	48	48	31	28
38	42	54	51	49	51	51	48	31
39	42	47	52	51	51	51	51	48
36	39	41	47	51	50	48	50	39
36	33	35	40	46	50	48	38	31

AVE = 38.8

SD = 8.4

CHANNEL 6

39	39	38	36	35	34	33	33	33
39	39	37	34	33	34	33	34	34
40	39	36	34	38	39	31	33	34
39	37	35	42	56	50	35	31	34
36	36	41	55	53	52	51	36	32
42	47	96	54	53	54	55	51	35
44	47	51	55	54	54	54	55	52
40	44	47	51	54	53	52	54	43
40	38	39	45	50	54	52	41	35

AVE = 42.7

SD = 8.2

(Continued)

Table C1 (Concluded)

CHANNEL 7

36	36	35	34	32	32	31	31	31
37	37	34	32	31	32	32	31	32
38	36	34	32	36	38	30	32	32
36	35	33	40	54	49	33	30	32
33	34	39	53	51	50	50	34	30
41	46	55	53	51	53	53	49	34
44	47	50	53	51	52	53	53	51
38	44	47	49	52	51	50	52	42
38	35	38	45	49	52	50	40	32

AVE = 40.9

SD = 8.4

CHANNEL 8

44	44	43	42	41	41	40	40	39
44	44	42	40	40	41	40	40	40
45	44	43	40	46	46	39	40	40
44	43	41	49	64	60	43	39	40
42	42	49	63	62	62	61	44	39
52	57	65	64	63	64	63	60	44
56	60	62	64	63	63	64	64	62
47	56	60	61	63	63	61	63	54
46	44	49	57	62	62	62	52	41

AVE = 50.7

SD = 9.7

CHANNEL 9

39	40	38	39	39	38	37	38	36
40	39	38	36	39	39	38	38	38
41	40	39	35	47	49	36	38	37
40	39	39	52	78	71	43	35	38
39	39	52	77	74	73	73	46	35
65	70	80	78	74	78	77	72	48
68	81	77	77	76	76	78	78	75
45	71	81	76	75	75	73	76	63
41	41	56	76	78	75	75	62	38

AVE = 55.6

SD = 17.6

CHANNEL 10

28	27	27	27	28	27	28	28	28
28	28	28	26	29	29	28	28	27
28	28	28	29	33	38	26	28	28
29	29	28	36	58	53	32	25	28
26	29	35	56	55	51	53	36	24
62	60	58	56	55	54	57	52	38
61	79	63	54	54	54	56	56	56
31	60	79	60	54	54	53	56	56
28	31	44	71	67	54	56	55	27

AVE = 42.1

SD = 15.2

CHANNEL 11

102	103	101	102	101	101	101	101	99
102	99	99	100	102	102	100	99	102
99	96	97	96	86	91	97	100	98
96	97	96	79	78	77	92	100	99
96	94	82	79	80	81	78	92	97
93	80	76	82	86	84	79	82	92
94	94	84	79	84	86	86	82	88
98	95	95	89	83	88	86	97	111
97	96	94	89	86	84	102	110	98

AVE = 92.6

SD = 8.5

Table C2

Summary of Spectral Data for Scan Line 790 and Pixel Number 409

SCAN LINE 790

PIXEL 409

CHANNEL	AVERAGE	STAND.DEV.
1	69.2	36.7
2	63.5	31.6
3	49.0	15.6
4	35.9	10.5
5	38.8	8.4
6	42.7	8.2
7	40.9	8.4
8	50.7	9.7
9	55.6	17.6
10	42.1	15.2
11	92.6	8.5

Table C3

Spectral Reflectance Data

Spectral Class	Band Number	Radiance Values	Percent Reflectance
Water 1	1	52	8.1
	2	53	10.4
	3	48	16.9
	4	40	19.8
	5	42	22.7
	6	45	24.7
	7	41	22.1
	8	47	21.9
	9	42	11.7
	10	31	10.1
Water 2	1	45	7.0
	2	40	7.9
	3	36	12.7
	4	26	12.9
	5	31	16.7
	6	36	19.7
	7	35	18.8
	8	49	22.8
	9	59	16.5
	10	45	14.6
Water 3	1	40	6.2
	2	35	6.9
	3	33	11.6
	4	23	11.4
	5	28	15.1
	6	32	17.6
	7	30	16.1
	8	39	18.2
	9	38	10.6
	10	30	9.8
Sand	1	241	37.5
	2	226	44.4
	3	140	49.4
	4	107	53.0
	5	103	55.6
	6	107	58.7
	7	110	59.2
	8	129	60.1
	9	216	60.3
	10	200	65.0

(Continued)

Table C3 (Continued)

Spectral Class	Band Number	Radiance Values	Percent Reflectance
Clay	1	50	7.8
	2	49	9.6
	3	44	15.5
	4	40	19.8
	5	57	30.8
	6	70	38.4
	7	74	39.8
	8	95	44.3
	9	136	38.0
	10	131	42.6
Grass	1	44	6.8
	2	41	8.1
	3	38	13.4
	4	29	14.4
	5	32	17.3
	6	37	20.3
	7	37	19.9
	8	61	28.4
	9	105	29.3
	10	105	34.1
Marsh	1	37	5.8
	2	34	6.7
	3	33	11.6
	4	23	11.4
	5	28	15.1
	6	33	18.1
	7	33	17.8
	8	47	21.9
	9	61	17.0
	10	61	19.8
Prairie	1	42	6.5
	2	40	7.9
	3	36	12.7
	4	26	12.9
	5	31	16.7
	6	36	19.7
	7	37	19.9
	8	51	23.8
	9	69	19.3
	10	70	22.8

(Continued)

Table C3 (Continued)

Spectral Class	Band Number	Radiance Values	Percent Reflectance
Forest 1	1	76	11.8
	2	54	10.6
	3	41	14.5
	4	29	14.4
	5	31	16.7
	6	34	18.7
	7	33	17.8
	8	57	26.6
	9	117	32.7
	10	99	32.2
Forest 2	1	75	11.7
	2	51	10.0
	3	39	13.8
	4	27	13.4
	5	30	16.2
	6	33	18.1
	7	31	16.7
	8	53	24.7
	9	94	26.2
	10	82	26.7
Wooden structures	1	68	10.6
	2	60	11.8
	3	47	16.6
	4	33	16.3
	5	36	19.4
	6	41	22.5
	7	41	22.1
	8	55	25.6
	9	71	19.8
	10	68	22.1
Concrete structures	1	77	12.0
	2	73	14.3
	3	55	19.4
	4	40	19.8
	5	44	23.8
	6	49	26.9
	7	49	26.4
	8	62	28.9
	9	81	22.6
	10	74	24.0

(Continued)

Table C3 (Concluded)

Spectral Class	Band Number	Radiance Values	Percent Reflectance
Metal structures	1	140	21.8
	2	124	24.4
	3	75	26.5
	4	53	26.3
	5	53	28.6
	6	56	30.7
	7	54	29.1
	8	66	30.7
	9	82	22.9
	10	63	20.5
Asphalt structures	1	63	9.8
	2	56	11.0
	3	45	15.9
	4	32	15.9
	5	37	20.0
	6	42	23.0
	7	41	22.1
	8	53	24.7
	9	65	18.1
	10	59	19.2

(Sheet 4 of 4)

Table C4

Film-Filter Matrix for Film Type 2402 and Filter Type 12

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.17	0.26	0.13	0.66	0.23	0.17	0.24	0.16	0.20	0.06
Water 2	0.17		0.09	0.04	0.83	0.06	0.00	0.41	0.41	0.02	0.11
Grass	0.13	0.04	0.13		0.79	0.10	0.04	0.37	0.03	0.06	0.07
Wooden Structure	0.06	0.11	0.20	0.07	0.72	0.18	0.11	0.30	0.10	0.14	0.00
Concrete Structure	0.06	0.24	0.32	0.20	0.59	0.30	0.23	0.17	0.23	0.26	0.17
Metal Structure	0.18	0.36	0.44	0.32	0.47	0.42	0.35	0.05	0.35	0.38	0.25
Sand	0.66	0.83	0.92	0.79		0.89	0.83	0.42	0.82	0.85	0.72
Marsh	0.23	0.06	0.02	0.10	0.89		0.07	0.47	0.07	0.04	0.17
Prairie	0.17	0.00	0.09	0.04	0.83	0.07		0.40	0.00	0.03	0.10
Clay	0.24	0.41	0.50	0.37	0.42	0.47	0.40		0.40	0.43	0.30
Forest 1	0.16	0.41	0.10	0.03	0.82	0.07	0.00	0.40		0.03	0.10
Forest 2	0.20	0.02	0.06	0.06	0.85	0.04	0.03	0.43	0.03		0.13
Asphalt Structure	0.06	0.11	0.20	0.07	0.72	0.17	0.10	0.30	0.10	0.13	

Table C5

Film-Filter Matrix for Film Type 2403 and Filter Type 12

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.13	0.20	0.11	0.51	0.18	0.13	0.21	0.14	0.16	0.05
Water 2	0.13		0.07	0.02	0.64	0.05	0.00	0.34	0.34	0.03	0.08
Grass	0.11	0.02	0.09		0.62	0.07	0.02	0.32	0.03	0.06	0.06
Wooden Structure	0.05	0.08	0.15	0.06	0.56	0.13	0.08	0.25	0.09	0.12	0.00
Concrete Structure	0.05	0.18	0.25	0.16	0.46	0.23	0.18	0.16	0.19	0.21	0.10
Metal Structure	0.14	0.27	0.34	0.25	0.37	0.32	0.27	0.07	0.28	0.30	0.19
Sand	0.51	0.64	0.71	0.62		0.69	0.64	0.30	0.65	0.67	0.56
Marsh	0.18	0.05	0.02	0.07	0.69		0.05	0.39	0.04	0.02	0.13
Prairie	0.13	0.00	0.07	0.02	0.64	0.05		0.33	0.01	0.04	0.08
Clay	0.21	0.34	0.41	0.32	0.30	0.39	0.33		0.35	0.37	0.25
Forest 1	0.14	0.34	0.06	0.03	0.65	0.04	0.01	0.35		0.02	0.09
Forest 2	0.16	0.03	0.04	0.06	0.67	0.02	0.04	0.37	0.02		0.12
Asphalt Structure	0.05	0.08	0.15	0.06	0.56	0.13	0.08	0.25	0.09	0.12	

Table C6

Film-Filter Matrix for Film Type 2402 and Filter Type 47B

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.12	0.17	0.11	0.88	0.19	0.12	0.01	0.09	0.07	0.06
Water 2	0.12		0.06	0.01	1.00	0.07	0.01	0.11	0.11	0.19	0.17
Grass	0.11	0.01	0.07		0.99	0.09	0.02	0.10	0.20	0.18	0.16
Wooden Structure	0.09	0.21	0.26	0.20	0.79	0.28	0.22	0.10	0.00	0.02	0.04
Concrete Structure	0.19	0.30	0.36	0.29	0.70	0.38	0.31	0.19	0.09	0.11	0.13
Metal Structure	0.51	0.63	0.68	0.62	0.37	0.70	0.63	0.52	0.42	0.44	0.45
Sand	0.88	1.00	1.06	0.99		1.08	1.01	0.89	0.79	0.81	0.83
Marsh	0.19	0.07	0.02	0.09	1.08		0.07	0.18	0.28	0.26	0.25
Prairie	0.12	0.01	0.05	0.02	1.01	0.07		0.12	0.22	0.20	0.18
Clay	0.01	0.11	0.17	0.10	0.89	0.18	0.12		0.10	0.08	0.06
Forest 1	0.09	0.11	0.26	0.20	0.79	0.28	0.22	0.10		0.02	0.04
Forest 2	0.07	0.19	0.24	0.18	0.81	0.26	0.20	0.08	0.02		0.02
Asphalt Structure	0.06	0.17	0.23	0.16	0.83	0.25	0.18	0.06	0.04	0.02	

Table C7

Film-Filter Matrix for Film Type 2403 and Filter Type 47B

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.09	0.13	0.09	0.70	0.15	0.10	0.02	0.08	0.06	0.05
Water 2	0.09		0.04	0.00	0.79	0.06	0.01	0.07	0.07	0.15	0.14
Grass	0.09	0.00	0.04		0.79	0.06	0.01	0.07	0.16	0.15	0.13
Wooden Structure	0.07	0.17	0.21	0.16	0.62	0.23	0.17	0.09	0.00	0.01	0.03
Concrete Structure	0.15	0.24	0.28	0.24	0.55	0.30	0.25	0.17	0.07	0.08	0.10
Metal Structure	0.41	0.50	0.54	0.50	0.29	0.56	0.51	0.43	0.33	0.35	0.36
Sand	0.70	0.79	0.83	0.79		0.85	0.80	0.72	0.62	0.64	0.65
Marsh	0.15	0.06	0.02	0.06	0.85		0.05	0.13	0.23	0.21	0.20
Prairie	0.10	0.01	0.03	0.01	0.80	0.05		0.08	0.18	0.16	0.15
Clay	0.02	0.07	0.11	0.07	0.72	0.13	0.08		0.09	0.08	0.06
Forest 1	0.08	0.07	0.21	0.16	0.62	0.23	0.18	0.09		0.01	0.03
Forest 2	0.06	0.15	0.19	0.15	0.64	0.21	0.16	0.08	0.01		0.02
Asphalt Structure	0.05	0.14	0.18	0.13	0.65	0.20	0.15	0.06	0.03	0.02	

Table C8

Film-Filter Matrix for Film Type 2402 and Filter Type 58

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.22	0.28	0.17	0.70	0.29	0.23	0.00	0.15	0.18	0.08
Water 2	0.22		0.06	0.05	0.92	0.07	0.01	0.22	0.22	0.04	0.13
Grass	0.17	0.05	0.11		0.87	0.11	0.06	0.18	0.02	0.00	0.09
Wooden Structure	0.06	0.15	0.22	0.11	0.76	0.22	0.16	0.07	0.08	0.11	0.02
Concrete Structure	0.05	0.27	0.33	0.22	0.65	0.34	0.28	0.05	0.20	0.23	0.14
Metal Structure	0.25	0.46	0.53	0.42	0.45	0.53	0.47	0.24	0.39	0.42	0.33
Sand	0.70	0.92	0.98	0.87		0.98	0.93	0.69	0.85	0.87	0.78
Marsh	0.29	0.07	0.00	0.11	0.98		0.06	0.29	0.14	0.11	0.20
Prairie	0.23	0.01	0.05	0.06	0.93	0.06		0.23	0.08	0.05	0.14
Clay	0.00	0.22	0.28	0.18	0.69	0.29	0.23		0.15	0.18	0.09
Forest 1	0.15	0.22	0.13	0.02	0.85	0.14	0.08	0.15		0.03	0.06
Forest 2	0.18	0.04	0.10	0.00	0.87	0.11	0.05	0.18	0.03		0.09
Asphalt Structure	0.08	0.13	0.20	0.09	0.78	0.20	0.14	0.09	0.06	0.09	

Table C9

Film-Filter Matrix for Film Type 2403 and Filter Type 58

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.18	0.23	0.14	0.55	0.23	0.19	0.00	0.13	0.15	0.07
Water 2	0.18		0.05	0.03	0.73	0.05	0.01	0.17	0.17	0.03	0.11
Grass	0.14	0.03	0.08		0.69	0.09	0.04	0.14	0.02	0.00	0.07
Wooden Structure	0.06	0.12	0.17	0.09	0.60	0.18	0.13	0.05	0.07	0.09	0.01
Concrete Structure	0.04	0.21	0.26	0.18	0.51	0.27	0.22	0.04	0.16	0.18	0.11
Metal Structure	0.19	0.37	0.42	0.34	0.36	0.42	0.38	0.20	0.32	0.34	0.26
Sand	0.55	0.73	0.77	0.69		0.78	0.73	0.55	0.67	0.70	0.62
Marsh	0.23	0.05	0.01	0.09	0.78		0.05	0.23	0.11	0.08	0.16
Prairie	0.19	0.01	0.04	0.04	0.73	0.05		0.18	0.06	0.04	0.12
Clay	0.00	0.17	0.22	0.14	0.55	0.23	0.18		0.12	0.14	0.07
Forest 1	0.13	0.17	0.10	0.02	0.67	0.11	0.06	0.12		0.02	0.06
Forest 2	0.15	0.03	0.08	0.00	0.70	0.08	0.04	0.14	0.02		0.08
Asphalt Structure	0.07	0.11	0.16	0.07	0.62	0.16	0.12	0.07	0.06	0.08	

Table C10

Film-Filter Matrix for Film Type 2402 and Filter Type 25A

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.13	0.23	0.09	0.65	0.19	0.12	0.34	0.15	0.18	0.03
Water 2	0.13		0.10	0.04	0.78	0.06	0.01	0.47	0.47	0.05	0.10
Grass	0.09	0.04	0.14		0.88	0.04	0.11	0.57	0.08	0.05	0.20
Wooden Structure	0.03	0.10	0.19	0.06	0.68	0.15	0.08	0.37	0.11	0.15	0.00
Concrete Structure	0.09	0.22	0.32	0.18	0.56	0.27	0.20	0.25	0.23	0.27	0.12
Metal Structure	0.17	0.30	0.40	0.27	0.48	0.36	0.29	0.16	0.32	0.35	0.21
Sand	0.65	0.78	0.88	0.74		0.84	0.77	0.31	0.79	0.83	0.68
Marsh	0.19	0.06	0.04	0.09	0.84		0.07	0.52	0.04	0.01	0.15
Prairie	0.12	0.01	0.11	0.02	0.77	0.07		0.45	0.03	0.06	
Clay	0.34	0.47	0.57	0.43	0.31	0.52	0.45		0.48	0.52	0.37
Forest 1	0.15	0.47	0.08	0.05	0.79	0.04	0.03	0.48		0.04	0.11
Forest 2	0.18	0.05	0.05	0.09	0.83	0.01	0.06	0.52	0.04		0.15
Asphalt Structure	0.03	0.10	0.20	0.06	0.68	0.15	0.08	0.37	0.11	0.15	

Table C11

Film-Filter Matrix for Film Type 2403 and Filter Type 25A

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.11	0.18	0.09	0.51	0.16	0.10	0.26	0.13	0.16	0.03
Water 2	0.11		0.07	0.02	0.62	0.05	0.01	0.37	0.37	0.05	0.08
Grass	0.09	0.02	0.09		0.60	0.07	0.01	0.35	0.04	0.07	0.06
Wooden Structure	0.03	0.08	0.15	0.06	0.54	0.12	0.07	0.29	0.10	0.13	0.00
Concrete Structure	0.06	0.17	0.25	0.15	0.44	0.22	0.16	0.20	0.20	0.22	0.09
Metal Structure	0.13	0.24	0.32	0.22	0.37	0.29	0.23	0.13	0.27	0.29	0.16
Sand	0.51	0.62	0.69	0.60		0.66	0.61	0.25	0.64	0.67	0.54
Marsh	0.16	0.05	0.03	0.07	0.66		0.06	0.42	0.02	0.00	0.12
Prairie	0.10	0.01	0.08	0.01	0.61	0.06		0.36	0.03	0.06	0.07
Clay	0.26	0.37	0.44	0.35	0.25	0.42	0.36		0.39	0.42	0.29
Forest 1	0.13	0.37	0.05	0.04	0.64	0.02	0.03	0.39		0.03	0.10
Forest 2	0.16	0.05	0.02	0.07	0.67	0.00	0.06	0.42	0.03		0.13
Asphalt Structure	0.03	0.08	0.15	0.06	0.54	0.12	0.07	0.29	0.10	0.13	

Table C12

Film-Filter Matrix for Film Type 2402 and Filter Type 3

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.18	0.26	0.14	0.68	0.24	0.17	0.20	0.15	0.18	0.06
Water 2	0.18		0.08	0.04	0.86	0.06	0.00	0.37	0.37	0.01	0.12
Grass	0.14	0.04	0.12		0.82	0.10	0.03	0.33	0.01	0.04	0.08
Wooden Structure	0.05	0.13	0.21	0.09	0.73	0.19	0.12	0.25	0.10	0.13	0.01
Concrete Structure	0.07	0.25	0.33	0.21	0.61	0.31	0.24	0.12	0.22	0.25	0.13
Metal Structure	0.22	0.40	0.48	0.36	0.46	0.46	0.39	0.02	0.37	0.40	0.28
Sand	0.68	0.86	0.94	0.82		0.92	0.85	0.48	0.83	0.86	0.74
Marsh	0.24	0.06	0.02	0.10	0.92		0.07	0.43	0.09	0.06	0.18
Prairie	0.17	0.00	0.08	0.03	0.85	0.07		0.37	0.02	0.01	0.12
Clay	0.20	0.37	0.45	0.33	0.48	0.43	0.37		0.34	0.38	0.25
Forest 1	0.15	0.37	0.11	0.01	0.83	0.09	0.02	0.34		0.03	0.09
Forest 2	0.18	0.01	0.08	0.04	0.86	0.06	0.01	0.38	0.03		0.12
Asphalt Structure	0.06	0.12	0.20	0.08	0.74	0.18	0.12	0.25	0.09	0.12	

Table C13

Film-Filter Matrix for Film Type 2403 and Filter Type 3

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.13	0.20	0.11	0.52	0.18	0.13	0.19	0.13	0.16	0.04
Water 2	0.13		0.07	0.02	0.66	0.05	0.00	0.32	0.32	0.02	0.09
Grass	0.11	0.02	0.09		0.63	0.07	0.02	0.30	0.02	0.04	0.07
Wooden Structure	0.04	0.09	0.16	0.07	0.57	0.14	0.09	0.23	0.09	0.11	0.00
Concrete Structure	0.05	0.19	0.25	0.17	0.47	0.24	0.18	0.13	0.19	0.21	0.10
Metal Structure	0.16	0.29	0.36	0.27	0.37	0.34	0.29	0.03	0.29	0.31	0.20
Sand	0.52	0.66	0.72	0.63		0.71	0.65	0.34	0.65	0.68	0.57
Marsh	0.18	0.05	0.02	0.07	0.71		0.05	0.37	0.05	0.03	0.14
Prairie	0.13	0.00	0.07	0.02	0.65	0.05		0.32	0.00	0.02	0.09
Clay	0.19	0.32	0.38	0.30	0.34	0.37	0.32		0.32	0.34	0.23
Forest 1	0.13	0.32	0.07	0.02	0.65	0.05	0.00	0.32		0.02	0.09
Forest 2	0.16	0.02	0.04	0.04	0.68	0.03	0.02	0.34	0.02		0.11
Asphalt Structure	0.04	0.09	0.15	0.07	0.57	0.14	0.09	0.23	0.09	0.11	

Table C14

Film-Filter Matrix for Film Type 2448 and Filter Type 3

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.67	0.93	0.57	2.60	0.92	0.69	0.44	0.47	0.57	0.18
Water 2	0.67		0.25	0.10	3.27	0.25	0.02	0.93	0.93	0.23	0.49
Grass	0.57	0.10	0.35		3.17	0.35	0.12	0.83	0.21	0.18	0.39
Wooden Structure	0.18	0.54	0.79	0.44	2.73	0.79	0.56	0.57	0.34	0.44	0.06
Concrete Structure	0.30	0.97	1.22	0.87	2.30	1.22	0.99	0.58	0.77	0.87	0.48
Metal Structure	1.00	1.67	1.92	1.57	1.60	1.92	1.69	1.04	1.47	1.57	1.18
Sand	2.60	3.27	3.52	3.17		3.52	3.29	2.34	3.07	3.17	2.78
Marsh	0.92	0.25	0.06	0.35	3.52		0.23	1.18	0.45	0.35	0.74
Prairie	0.69	0.02	0.23	0.12	3.29	0.23		0.95	0.29	0.26	0.51
Clay	0.44	0.93	1.18	0.83	2.34	1.18	0.95		0.73	0.83	0.55
Forest 1	0.47	0.93	0.45	0.21	3.07	0.45	0.29	0.73		0.10	0.29
Forest 2	0.57	0.23	0.35	0.18	3.17	0.35	0.26	0.83	0.10		0.39
Asphalt Structure	0.18	0.49	0.74	0.39	2.78	0.74	0.51	0.55	0.29	0.39	

Table C15

<u>Film-Filter Matrix for Film Type 2443 and Filter Type 3</u>

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.50	0.86	0.54	2.66	0.70	0.46	0.85	0.60	0.56	0.23
Water 2	0.50		0.36	0.29	3.17	0.20	0.07	1.32	1.32	0.29	0.43
Grass	0.54	0.29	0.65		2.88	0.49	0.24	1.03	0.16	0.16	0.31
Wooden Structure	0.25	0.48	0.84	0.29	2.69	0.68	0.44	0.84	0.35	0.32	0.06
Concrete Structure	0.40	0.91	1.26	0.62	2.26	1.10	0.86	0.60	0.57	0.75	0.48
Metal Structure	0.94	1.44	1.80	1.15	1.72	1.64	1.40	0.59	1.11	1.28	1.01
Sand	2.66	3.17	3.53	2.88		3.36	3.12	1.84	2.84	3.01	2.74
Marsh	0.70	0.20	0.19	0.49	3.36		0.24	1.52	0.53	0.36	0.63
Prairie	0.46	0.07	0.40	0.24	3.12	0.24		1.28	0.36	0.26	0.38
Clay	0.85	1.32	1.68	1.03	1.84	1.52	1.28		0.99	1.16	0.89
Forest 1	0.60	1.32	0.69	0.16	2.84	0.53	0.36	0.99		0.17	0.36
Forest 2	0.56	0.29	0.52	0.16	3.01	0.36	0.26	1.16	0.17		0.33
Asphalt Structure	0.23	0.43	0.79	0.31	2.74	0.63	0.38	0.89	0.36	0.33	

Table C16

Film-Filter Matrix for Film Type 2443 and Filter Type 12

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.48	0.88	0.65	2.61	0.66	0.55	0.98	0.73	0.68	0.30
Water 2	0.48		0.39	0.35	3.09	0.18	0.09	1.46	1.46	0.28	0.39
Grass	0.65	0.35	0.74		2.74	0.53	0.29	1.12	0.11	0.21	0.36
Wooden Structure	0.31	0.44	0.83	0.34	2.65	0.62	0.38	1.02	0.41	0.36	0.06
Concrete Structure	0.38	0.86	1.26	0.52	2.23	1.05	0.81	0.65	0.58	0.72	0.47
Metal Structure	0.80	1.29	1.68	0.94	1.80	1.47	1.23	0.68	0.95	1.14	0.89
Sand	2.61	3.09	3.48	2.74		3.27	3.03	1.63	2.76	2.95	2.70
Marsh	0.66	0.18	0.23	0.53	3.27		0.24	1.65	0.52	0.32	0.58
Prairie	0.55	0.09	0.45	0.29	3.03	0.24		1.41	0.35	0.23	0.33
Clay	0.98	1.46	1.86	1.12	1.63	1.65	1.41		1.13	1.32	1.07
Forest 1	0.73	1.46	0.73	0.11	2.76	0.52	0.35	1.13		0.19	0.43
Forest 2	0.68	0.28	0.54	0.21	2.95	0.32	0.23	1.32	0.19		0.38
Asphalt Structure	0.30	0.39	0.79	0.36	2.70	0.58	0.33	1.07	0.43	0.38	

Table C17

Film-Filter Matrix for Film Type 2424 and Filter Type 12

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.03	0.14	0.27	0.81	0.03	0.10	0.51	0.31	0.20	0.11
Water 2	0.03		0.18	0.24	0.78	0.01	0.06	0.48	0.48	0.17	0.08
Grass	0.27	0.24	0.41		0.54	0.24	0.18	0.24	0.03	0.07	0.16
Wooden Structure	0.14	0.11	0.28	0.13	0.67	0.11	0.05	0.37	0.16	0.06	0.03
Concrete Structure	0.24	0.20	0.38	0.04	0.58	0.21	0.14	0.28	0.07	0.03	0.12
Metal Structure	0.28	0.25	0.42	0.01	0.53	0.25	0.18	0.23	0.03	0.08	0.17
Sand	0.81	0.78	0.96	0.54		0.78	0.72	0.30	0.51	0.61	0.70
Marsh	0.03	0.01	0.17	0.24	0.78		0.07	0.49	0.28	0.17	0.08
Prairie	0.10	0.06	0.24	0.18	0.72	0.07		0.42	0.21	0.11	0.02
Clay	0.51	0.48	0.66	0.24	0.30	0.49	0.42		0.21	0.31	0.40
Forest 1	0.31	0.48	0.45	0.03	0.51	0.28	0.21	0.21		0.10	0.19
Forest 2	0.20	0.17	0.34	0.07	0.61	0.17	0.11	0.31	0.10		0.09
Asphalt Structure	0.11	0.08	0.25	0.16	0.70	0.08	0.02	0.40	0.19	0.09	

Table C18

Film-Filter Matrix for Film Type 2424 and Filter Type 25A

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.06	0.13	0.31	0.83	0.06	0.13	0.55	0.35	0.24	0.13
Water 2	0.06		0.19	0.25	0.78	0.00	0.07	0.49	0.49	0.18	0.08
Grass	0.31	0.25	0.44		0.52	0.25	0.18	0.24	0.04	0.07	0.18
Wooden Structure	0.17	0.11	0.29	0.14	0.67	0.11	0.04	0.39	0.18	0.07	0.03
Concrete Structure	0.26	0.20	0.39	0.05	0.58	0.20	0.13	0.29	0.09	0.02	0.12
Metal Structure	0.29	0.23	0.42	0.02	0.54	0.23	0.16	0.26	0.05	0.05	0.16
Sand	0.83	0.78	0.96	0.52		0.78	0.71	0.28	0.49	0.60	0.70
Marsh	0.06	0.00	0.19	0.25	0.78		0.07	0.49	0.29	0.18	0.08
Prairie	0.13	0.07	0.25	0.18	0.71	0.07		0.43	0.22	0.11	0.01
Clay	0.55	0.49	0.68	0.24	0.28	0.49	0.43		0.21	0.31	0.42
Forest 1	0.35	0.49	0.47	0.04	0.49	0.29	0.22	0.21		0.11	0.21
Forest 2	0.24	0.18	0.37	0.07	0.60	0.18	0.11	0.31	0.11		0.10
Asphalt Structure	0.13	0.08	0.26	0.18	0.70	0.08	0.01	0.42	0.21	0.10	

Table C19

Film-Filter Matrix for Film Type 2424 and Filter Type 87C

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.20	0.06	0.57	1.03	0.23	0.31	0.74	0.64	0.50	0.27
Water 2	0.20		0.26	0.37	0.83	0.03	0.10	0.54	0.54	0.30	0.07
Grass	0.57	0.37	0.63		0.46	0.34	0.26	0.17	0.07	0.07	0.30
Wooden Structure	0.32	0.12	0.39	0.25	0.71	0.09	0.02	0.41	0.32	0.18	0.05
Concrete Structure	0.41	0.21	0.47	0.16	0.63	0.18	0.10	0.33	0.23	0.09	0.14
Metal Structure	0.41	0.21	0.48	0.16	0.62	0.18	0.11	0.32	0.23	0.09	0.14
Sand	1.03	0.83	1.10	0.46		0.80	0.73	0.30	0.39	0.53	0.76
Marsh	0.23	0.03	0.29	0.34	0.80		0.07	0.51	0.41	0.27	0.04
Prairie	0.31	0.10	0.37	0.26	0.73	0.07		0.43	0.34	0.20	0.03
Clay	0.74	0.54	0.80	0.17	0.30	0.51	0.43		0.10	0.24	0.47
Forest 1	0.64	0.54	0.70	0.07	0.39	0.41	0.34	0.10		0.14	0.37
Forest 2	0.50	0.30	0.56	0.07	0.53	0.27	0.20	0.24	0.14		0.23
Asphalt Structure	0.27	0.07	0.33	0.30	0.76	0.04	0.03	0.47	0.37	0.23	

Table C20

<u>Film-Filter Matrix for Film Type 2424 and Filter Type 89B</u>

Feature \ Background	Water 1	Water 2	Water 3	Grass	Sand	Marsh	Prairie	Clay	Forest 1	Forest 2	Asphalt Structure
Water 1		0.19	0.07	0.54	1.00	0.21	0.28	0.71	0.60	0.47	0.25
Water 2	0.19		0.25	0.35	0.82	0.03	0.10	0.53	0.53	0.29	0.07
Grass	0.54	0.35	0.60		0.47	0.33	0.25	0.18	0.07	0.07	0.28
Wooden Structure	0.31	0.12	0.37	0.23	0.70	0.09	0.02	0.41	0.30	0.17	0.05
Concrete Structure	0.39	0.20	0.45	0.15	0.62	0.18	0.10	0.33	0.22	0.08	0.13
Metal Structure	0.40	0.21	0.46	0.14	0.61	0.18	0.11	0.32	0.21	0.07	0.14
Sand	1.00	0.82	1.07	0.47		0.79	0.72	0.29	0.40	0.53	0.75
Marsh	0.21	0.03	0.28	0.33	0.79		0.07	0.50	0.39	0.26	0.04
Prairie	0.28	0.10	0.35	0.25	0.72	0.07		0.43	0.32	0.19	0.03
Clay	0.71	0.53	0.78	0.18	0.29	0.50	0.43		0.11	0.24	0.46
Forest 1	0.60	0.53	0.67	0.07	0.40	0.39	0.32	0.11		0.13	0.35
Forest 2	0.47	0.29	0.54	0.07	0.53	0.26	0.19	0.24	0.13		0.22
Asphalt Structure	0.25	0.07	0.32	0.28	0.75	0.04	0.03	0.46	0.35	0.22	

APPENDIX D: STATE LAWS AFFECTING PERMIT ACTIONS IN MOBILE DISTRICT COASTAL AREAS

1. The following discussion of State laws presents a brief summary of legislation potentially pertinent to the decisionmaking process in the granting of permits or evaluating of real or possible violations of the Corps permit program. The summaries are not intended to be taken as comprehensive, but rather as a selected list of source material from which further information may be obtained. All possible attempts have been made to ensure that the citations of laws are accurate and that comments represent the best available data provided to the WES during the course of this study (through early summer of 1978).

Alabama

2. The Code of Alabama, 1975,[26]* was recently adopted by the State (October 1977), and the titles of the older code have been replaced by a system using section headings. Within the Code, two sections (9 and 22), deal with most of the jurisdictional areas where permit actions would be involved.

3. Within section 9, the following topics are pertinent:

   a. Section 9-1-1 - the Alabama Department of Conservation and management of State Park lands.

   b. Section 9-7-10 - preservation and development of coastal areas.

   c. Section 9-7-20 - permits within the coastal area.

   d. Section 9-11-300 - wildlife management.

   e. Section 9-15-1 - supervision of public lands.

   f. Section 9-16-30 - surface mining.

4. Within section 22, the following may relate to the Corps:

   a. Section 22-22-1 - the Alabama Water Improvement Commission and the subject of State water-quality permits.

   b. Section 22-27-1 - solid waste control.

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* Reference numbers refer to similarly numbered items in the list of references following the main text on page 115.

5. The Alabama Coastal Area Board, the primary State agency for developing, coordinating, and maintaining the State's coastal area program, was created in 1973 by the Coastal Area Development Act. The Board's staff and technical resources were designed to operate through the Alabama Development Office, and the Board was directed to develop a coastal area administration program within which a permit program for regulating coastal activities would be followed.

6. The 1976 State legislature passed Coastal Area Development Act No. 534, through which the 1973 Act was repealed. The 1976 Act provided for changes in membership in the Coastal Area Board and the development of a technical staff and also defined the boundary of the coastal zone, along with several other actions. Currently, the Board is located in Daphne and is engaged in an active citizen's involvement program aimed toward the final organization of a coastal area plan to satisfy the requirements of the Federal Coastal Zone Management Act of 1972. The extent of the currently defined coastal area is shown in Figure D1.

7. A number of State offices can provide information concerning State regulations and permit requirements for activities which are of interest to the District's regulatory functions. A list of selected State offices for information, with addresses and telephone numbers (current to mid-1977) is given in Table D1.

Mississippi

8. The Mississippi Code of 1972,[30] annotated, and the 1976 Cumulative Supplement for the legislative sessions of 1972-1976 list four titles which discuss State laws that could be of interest to the Mobile District's Regulatory Functions Branch personnel:

- a. Title 29 - Public lands, buildings, and property.
- b. Title 49 - Conservation and ecology.
- c. Title 51 - Waters, water resources, water districts, drainage, and flood control.
- d. Title 55 - Park recreation.

9. Within Title 29, Chapters 1 and 3 lay the framework for the policy concerning the State's public lands. Of particular interest to

Figure D1. Extent of the currently defined Alabama coastal area

the Mobile District is the fact that activities performed within the State's sixteenth section and lieu lands are controlled and administered by County Boards of Supervisors and Superintendents of Education. The locations of sixteenth section lands can be determined from standard USGS 7.5-ft or 15-ft topographic sheets to ascertain the applicability of the provisions of this title to a permit applicant. The lieu lands form a much smaller group of controlled public lands lying mainly within the southern Mississippi counties. The locations of these lands as defined by the Mississippi State Land Commissioner are given in Table D2.

10. Title 49, Chapter 5, Sections 101-119, outline State policies for nongame and endangered species conservation and the protection of the habitats of such species. Chapter 17 covers State policies on air, water, and stream pollution and establishes a permit program designed toward the control and prevention of the discharge of contaminants and waste products into the air and waters of the State. Chapter 27 develops the framework for the Mississippi Coastal Wetlands Protection Law of 1973. Prior to this law, the Mississippi Marine Resources Council acted as an advisory body with no real regulatory functions. With the advent of the Protection Law, the coastal zone was defined, regulated activities were identified, and a permit program for coastal zone activities was developed. The coastal zone boundaries that were developed at this time represented two areas: the State's normal regulatory activity that proceeded to the ordinary high water mark and the previously unregulated coastal wetlands above the ordinary high water mark. This is the set of conditions represented by the coastal zone boundaries delineated in the Marine Resource Council's atlas of coastal wetlands photomaps.[28] To aid in alleviating the problem of coastal wetlands not regulated by the State, the 1978 Mississippi legislature passed two bills, one of which will be of particular interest to the Corps. Senate Bill 2498 directs the Marine Resources Council to manage the State's coastal wetlands and to act in behalf of the State, with other Federal or State agencies, in matters concerning the coastal wetlands. At present, the effects of this bill have not been fully realized and it will be some time before the legal framework for the

Council's new activities are clearly defined.[39]

11. Title 51 addresses several areas of interest to the Corps permit program. These chapters are:

a. Chapter 1 - navigable waters.

b. Chapter 3 - vegetation and control of surface waters.

c. Chapter 4 - groundwaters and a permit program for users of groundwater supplies.

d. Chapter 7 - State water management districts.

12. Title 55 considers the State parks and forests of Mississippi in Chapter 3, and Chapter 5 covers Federal Parks and National Parkways within Mississippi.

13. A list of selected useful State offices, with addresses and telephone numbers (current to mid-1977) is given in Table D3.

Louisiana

14. As stated earlier in this report (see paragraph 149), the state of Louisiana occupies a small portion of the jurisdictional area within the Mobile District. But since there are parts of three parishes (St. Tammany, Tangipahoa, and Washington) that fall within the Mobile District, the laws of Louisiana affecting the coastal areas should be identified.

15. During the 1977 legislature, Act No. 705 was passed with the intended purpose of creating a coastal management program aimed at satisfying the Federal Office of Coastal Zone Management (OCZM) requirements for Federal funding. The Act defined a State coastal area that extended approximately 3 miles inland from the Gulf of Mexico. This plan was not accepted when submitted to OCZM, primarily due to inadequate management structure and the omission of areas considered critical to the coastal environment. At present, there does not exist any comprehensive permitting program for activities within the Louisiana coastal areas. Current planning calls for the coastal program of the State to be reworked in the 1978 legislature, and it is possible that the newly defined zone will extend at least in many areas to the high tide mark currently used by the Corps for much of its work.

16. The Louisiana Revised Statutes of 1950, as amended, do list many activities in coastal areas that require permits or any regulated by the State. Some of the pertinent titles and sections are given in the following discussion from a summary[40] prepared by Mr. Frank Craig, Senior Research Associate of the Louisiana State University Sea Grant Legal Program:

> a. La.R.S. 30:4 gives the Department of Natural Resources the authority to promulgate regulations for various purposes, including the issuance of "certificates of clearance ... in connection with the transportation of oil, gas, or any product."
>
> b. La.R.S. 38:2 lists the functions of the Department of Public Works (DPW) (transferred to the Department of Transportation and Development as of 1 July 1977, see R.S. 36:509) to include "the planning, design, survey ... levees, canals, dams, locks, spillways, reservoirs, drainage systems, irrigation systems, ... inland navigation projects, flood control and river improvement projects ..."
>
> c. La.R.S. 38:18 requires the DPW to confer with the Department of Wildlife and Fisheries (DWF) on every project affecting wetlands, regardless of the State-Federal, state, parish, or state-parish nature of the project.

17. If any proposed construction requires the laying of pipe through, in, or under any public levee, generally the consent of the levee district, the DPW, and the concerned governing body is required (La.R.S. 38:221). Levee districts themselves are authorized to acquire land to construct recreational facilities (La.R.S. 32:281).

18. Obstruction of the free passage of fish in any body of water "by any means whatsoever" is prohibited by La.R.S. 56:329.

19. If public land is involved, La.R.S. 41:1173 allows the governor and the secretary of Natural Resources to grant a right-of-way across and through public lands. State lands may be leased, La.R.S. 41:1212, and State lands, including the bodies and beds of navigable waters, may be leased "for the purpose of granting to the lessee the right to erect and use on the leased premises tanks and facilities for the receipt, storage, transportation, and shipment of oil, goods,

wares, and merchandise ... ." La.R.S. 41:1262. In 1968 La.R.S. 41:1501 *et seq.* was added to the revised statutes to permit the State to lease reclaimed bottoms of State-owned water bodies to State entities for public recreational purposes. La.R.S. 30:211 *et seq.* requires a permit from the State Mineral Board (now in the Department of Natural Resources) "to conduct geophysical and geological surveys on state-owned lands and water bottoms."

20. Louisiana regulates the activities of several industries which are so affected with the public interest as to be public utilities. Canals are regulated by the Department of Public Service, La.R.S. 45:62-71, as are telegraphs and the telephones, La.R.S. 781-790, both of which may be constructed in coastal areas. La.R.S. 781 assures telephone and telegraph companies of the right to construct lines "along and over the waters of the state." Pipelines, which are frequently constructed in wetland areas, are also regulated by the Department of Public Service pursuant to La.R.S. 45:253. Pipeline companies are specifically granted the right to expropriate property and to maintain works across, over, under, or along any navigable stream. State regulation of construction may have been increased by legislation passed in 1968 which requires gas pipelines to comply with section 8 of the U.S.A. Standard Code for Pressure Piping, Gas Transmission and Distribution Piping Systems. The Department may also impose any uniform pipeline safety standards which are promulgated by a Federal regulatory agency (La.R.S. 45:308).

21. Finally, it should be noted that the Fifth Circuit in Zabel v. Tabb, 430 F.2d 199 (1970), interpreted the Fish and Wildlife Coordination Act, 16 U.S.C. 661 *et seq.*, to require consultation with the State agency having control over wildlife for any project requiring a dredge and fill permit from the Corps of Engineers.

22. Activities involving dredging, filling, spoil disposal, and related matters are regulated in an apparently fragmented manner with authority split in many instances between the Stream Control Commission and the Louisiana Wildlife and Fisheries Commission. However, due to the reorganization of the executive branch, mandated by the 1974

Constitution, these bodies, along with many others, now are part of the Department of Wildlife and Fisheries. Thus, La.R.S. 36:609C gives the Office of Coastal and Marine Resources of DWF authority over the dredging of shells, sand, gravel, and fill materials. Moreover, the Office controls the important functions of water pollution control and prevention and waste disposal. Other important statutes are:

a. La.R.S. 38:216, which grants authority to the Stream Control Commission to stop, regulate, control, or restrain discharges of waste material.

b. La.R.S. 56:1431 *et seq.* and 1451 *et seq.* which give the authorities of the Stream Control Commission. Of particular interest are La.R.S. 56:1434, giving the Commission control of waste disposal, both public and private, "into any of the waters of the state or any tributaries or drains flowing into any of such waters," and La.R.S. 56:1439, which establishes the Commission's right to control pollution by either rule or order. La.R.S. 56:1451 requires the DWF to supervise "all drainage of saltwater and other noxious substances into the natural streams of the state."

23. There is no separate scheme for protecting water bodies and wetlands in the State's interior. All of the statutes discussed in relation to discharges, dredging, and filling apply to inland waters as well as to coastal water bodies.

24. The management and control of water bodies and wetlands is primarily conducted, at least from an environmental standpoint, by the Department of Wildlife and Fisheries (DWF), the authority of which is outlined above. The Department also administers the State game and fish preserves and sanctuaries, a list of which is given in La.R.S. 56:801. Moreover, DWF is charged with the administration of the Natural and Scenic Rivers System, La.R.S. 56:1841 *et seq.* Besides preventing the pollution of these waters, DWF is empowered to prohibit the "channelization, clearing and snagging, channel realignment, and reservoir construction of these rivers and streams..." (La.R.W. 56:1845).

25. A great deal of authority over water bodies and their adjacent wetlands (if any) has been delegated to special districts to deal with the local problems of flood control, drainage, and irrigation. There are numerous levee districts in the State (see, e.g., La.R.S.

38:141 *et seq.*) which have the authority to expropriate land adjacent to water bodies to build protection levees. Individual parishes may build back and side levees if they are subject to tidal overflow (La.R.S. 38:143), and incorporated cities and towns may build and maintain levees within their corporate limits. One interesting provision permits levee districts to dedicate artificial waterways as public, navigable waterways (La.R.S. 38:291). Besides levee districts, there are gravity drainage districts (see, e.g., 38:1751 *et seq.*), levee and drainage ditches (see e.g., 38:1951 *et seq.*), and irrigation districts (see, e.g., 38:2101, *et seq.*), all of which exercise some control over water bodies within their jurisdiction. Wetlands may also be controlled by other State or local agencies, such as school districts. La.R.S. 41:761 specifically permits a school district to sell a sixteenth section donated to the State by Congress for school purposes if the section is located in a township which is swamp or sea marsh and is therefore not habitable.

26. A list of State offices to which inquiries can be directed for information concerning Louisiana laws is given in Table D4.

Georgia

27. The portion of the State of Georgia regulated by the Mobile District does not include any coastal wetland areas; however, within the interior there are several parts of the Georgia Code[41] that involve State regulation of certain activities. Those laws that may affect the District's permit program and may require applicants to obtain State permits or licenses are:

a. Georgia Code, Chapter 43-16, Solid Waste Management Act - storage, collection, transportation, utilization, processing, disposal, and disposal facility construction or operation.

b. Georgia Code, Chapter 43-14, Georgia Surface Mining Act of 1968.

c. Georgia Code, Chapter 17-5, Georgia Water Quality Control Act, as amended - discharge of sewage, industrial wastes, or other wastes into State waters.

d. Georgia Code, Chapter 88-26, Georgia Water Supply Quality Control Act, as amended - operation of public or community water supply systems.

e. Georgia Code, Chapter 17-11, Georgia Water Use Act of 1972, as amended - industrial usage in excess of 100,000 gal/day of groundwaters by industries.

f. Georgia Code, Chapter 45-1, Coastal Marshlands Protection Act of 1972, as amended - all activities and structures that alter any marshlands within Georgia, except certain types of defined activities.

g. Georgia Code, Chapter 43-7, Oil and Gas Deep Drilling Act of 1975 - drilling and using wells for exploration or production.

h. Georgia Code, Chapter 5-23A, Erosion and Sedimentation Act of 1975 - regulation of soil erosion and sediment deposition onto lands and into waters of the State.

i. Georgia Code, Act No. 231, Georgia Safe Drinking Water Act of 1977 - covers provisions to be used by the Department of Natural Resources to ensure adequate water of sufficiently high quality to supply the needs of water supply systems within the State.

j. Georgia Code, The Protected Species Act of 1978 - provides for a State management program to protect endangered plant and animal species within the State.

28. Rules and regulations pertaining to some of the above laws are given in:

a. Georgia Code, Chapter 39-3-3, amended - administration of surface mining regulations and reclamation of lands affected by surface mining.

b. Georgia Code, Chapter 391-3-6 - administrative and enforcement rules to be followed for compliance with the Georgia Water Quality Control Act and amendments and the Federal Water Pollution Control Act Amendments of 1972.

c. Georgia Code, Chapter 270-5-15 - administration of water supply quality control requirements.

d. Georgia Code, Chapter 391-3-2 - procedures and permit requirements for groundwater usage.

e. Georgia Code, Chapter 391-4-12 - procedures for administration of the Coastal Marshlands Protection Act of 1972.

f. Georgia Code, Chapter 391-3-5 - rules for the implementation of the Georgia Safe Drinking Water Act of 1977.

g. Georgia Code, Chapter 391-4-13 - rules for and regulations pertaining to the policies set forth in the Protected Species Act of 1978.

29. A selected list (current through mid-1977) of State offices sources for providing information concerning State laws and regulations is given in Table D5.

Table D1

State Office Sources of Information Useful to Mobile District Activities Within Alabama

ADJUTANT GENERAL
Adjutant General
Military Department
1720 Federal Drive
P. O. Box 1311 (36102)
Montgomery, AL 36109
(205) 272-6953

AGRICULTURE
Commissioner
Department of Agriculture and Industries
Richard Beard Building
1445 Federal Drive
P. O. Box 3336 (36109)
Montgomery, AL 36107
(205) 832-6693

AIR POLLUTION CONTROL
Director
Air Pollution Control Commission
Department of Public Health
645 S. McDonough Street
Montgomery, AL 36130
(205) 834-6570

ARCHIVES AND RECORDS
Director
Department of Archives and History
Archives and History Building
624 Washington Avenue
Montgomery, AL 36130
(205) 832-6510

ATTORNEY GENERAL
Attorney General
Administrative Building
64 N. Union Street
Montgomery, AL 36130
(205) 834-5150

COMMERCE
Director
Development Office
Office of the Governor
3734 Atlanta Highway
c/o State Capitol
Montgomery, AL 36130
(205) 832-6810

(Continued)

Table D1 (Continued)

ECONOMIC DEVELOPMENT
Director
Development Office
Office of the Governor
3734 Atlanta Highway
c/o State Capitol
Montgomery, AL 36130
(205) 832-6810

ENVIRONMENTAL AFFAIRS
Director
Environmental Health Administration
Department of Public Health
State Office Building
501 Dexter Avenue
Montgomery, AL 36130
(205) 832-3176

FISH AND GAME
Director
Division of Game and Fish
Department of Conservation and Natural Resources
Administrative Building
64 N. Union Street
Montgomery, AL 36130
(205) 832-6300

FORESTRY
State Forester
Forestry Commission
513 Madison Avenue
Montgomery, AL 36130
(205) 832-6587

GEOLOGY
State Geologist
Geological Survey
P. O. Drawer O
University, AL 35486
(205) 349-2852

HIGHWAYS
Director
Highway Department
State Highway Building
11 S. Union Street
Montgomery, AL 36130
(205) 832-5440

(Continued)

Table D1 (Continued)

HISTORIC PRESERVATION
Director
Department of Archives and History
Archives and History Building
624 Washington Avenue
Montgomery, AL 36130
(205) 832-6510

LAW ENFORCEMENT PLANNING
Director
Law Enforcement Planning Agency
Executive Park, Building F
2863 Fairlane Drive
Montgomery, AL 36111
(205) 832-6832

LEGISLATIVE RESEARCH
Director
Legislative Reference Service
State Capitol
Montgomery, AL 36130
(205) 832-3496

NATURAL RESOURCES
Commissioner
Department of Conservation and Natural Resources
Administrative Building
64 N. Union Street
Montgomery, AL 36130
(205) 832-6361

OIL AND GAS
State Geologist and Supervisor
Oil and Gas Board
P. O. Drawer O
University, AL 35486
(205) 349-2852

PARKS
Director
Division of State Parks
Department of Conservation and Natural Resources
Administrative Building
64 N. Union Street
Montgomery, AL 36130
(205) 832-6323

(Continued)

Table D1 (Concluded)

PLANNING
Director
Planning Division
Development Office
Office of the Governor
State Capitol
Montgomery, AL 36130
(205) 832-6400

PUBLIC UTILITIES
President
Public Service Commission
State Office Building
501 Dexter Avenue
P. O. Box 991 (36102)
Montgomery, AL 36130
(205) 832-3353

PUBLIC WORKS
Director
Building Commission
State Office Building
501 Dexter Avenue
Montgomery, AL 36130
(205) 832-3404

SOLID WASTE MANAGEMENT
Director
Division of Solid Waste and Vector Control
Environmental Health Administration
Department of Public Health
State Office Building
501 Dexter Avenue
Montgomery, AL 36130
(205) 832-6728

WATER RESOURCES
Director
Water Improvement Commission
Department of Public Health
State Office Building
501 Dexter Avenue
Montgomery, AL 36130
(205) 277-3630

Table D2

Lieu Lands Located in Hancock and Pearl River Counties, Mississippi

County Ownership	Description	No. of Acres
	Lands in Hancock County	
Hancock	Beginning at the SE corner of Section 27; thence North 4.65 chains; thence West 4.65 chains; thence South 4.65 chains; thence East 4.65 chains to place of beginning, Section 27, Township 5 South, Range 14 West	2.16
	SE 1/4; S 1/2 of NE 1/4; South 3.665 chains of NE 1/4 of NE 1/4 Section 17, Township 5 South, Range 15 West	247
	E 1/2 of NE 1/4; NW 1/4 of NE 1/4; NE 1/4 of NW 1/4, less the West 72 links thereof, Section 19, Township 5 South, Range 15 West	157.84
	E 1/2 of NE 1/4; E 1/2 of SW 1/4; NW 1/4 of SE 1/4; West 11 links of NE 1/4 of NW 1/4; NW 1/4 of NW 1/4; North 2.29 chains of SW 1/4 of NW 1/4, Section 22, Township 5 South, Range 15 West	245.16
	NW 1/4 of NE 1/4, less a strip 30 links wide off of West side thereof; North. 6.36 chains of SW 1/4 of NE 1/4 except the West 2.14 chains thereof, Section 26, Township 5 South, Range 15 West	50.60
	NE 1/4; NE 1/4 of NW 1/4; NW 1/4 of SE 1/4; SW 1/4 of SE 1/4, except the East 15 links thereof; the West 43 links of NE 1/4 of SE 1/4, Section 29, Township 5 South, Range 15 West	280
	NW 1/4 of NW 1/4 and North 8.98 chains of SW 1/4 of NW 1/4, Section 30, Township 5 South, Range 15 West	57.60
	NW 1/4 of NW 1/4 and the North 7.05 chains of SE 1/4 of NW 1/4, Section 24, Township 6 South, Range 16 West	54
Harrison	Beginning at a point 4.65 chains North and 3 chains and 48 3/4 links West of the SE corner of Section 27; thence North 86 links; thence West 58 1/8 links; thence South 86 links; thence	0.05

(Continued)

Table D2 (Concluded)

County Ownership	Description	No. of Acres
	Lands in Hancock County (Continued)	
Harrison (Continued)	East 58 1/8 links to place of beginning, Section 27, Township 5 South, Range 14 West	
	Beginning at a point 4.65 chains North and 4 chains and 6 7/8 links west of the SE corner of Section 27; thence North 86 links; thence West 58 1/8 links; thence South 86 links; thence East 58 1/8 links to place of beginning, Section 27, Township 5 South, Range 14 West	0.05
Pearl River	Beginning at the SE Corner of Section 22, thence North 2.51 chains, thence West 2.51 chains, thence South 2.51 chains, thence East 2.51 chains to beginning Section 22, Township 5 South, Range 14 West	0.63
	Lands in Pearl River County	
Adams	SE 1/4 of NW 1/4 W of Hwy 59 ROW & NW 1/4 SW 1/4 less 50' on N side and less Hwy 59 ROW Section 3, Township 5 South, Range 16 West	72.96
	S 1/2 NW 1/4 NE 1/4 & SW 1/4 NE 1/4 & NE 1/4 SE 1/4 Section 4, Township 5 South, Range 16 West	100
Jefferson	The South 4.01 chains of NE 1/4 of SE 1/4; the East 1.02 chains of SE 1/4 of SE 1/4, Section 24, Township 5 South, Range 16 West	10.10
Wilkinson	Beginning at a point 5.64 chains East of NW corner of Section 13, thence East 49 links; thence South 6.13 chains; thence West 49 links; thence North 6.13 chains to beginning, Section 13, Township 6 South, Range 16 West	0.30

Table D3

State Offices: Sources of Information Useful to Mobile District Activities Within Mississippi

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ADJUTANT GENERAL
Adjutant General
Military Department
P. O. Box 5027, Fondren Sta.
Jackson, MS 39216
(601) 354-7511

AGRICULTURE
Commissioner
Department of Agriculture and Commerce
1604 Walter Sillers Building
550 High Street
P. O. Box 1609 (39205)
Jackson, MS 39202
(601) 354-6563

ARCHIVES AND RECORDS
Director
Department of Archives and History
100 S. State Street
P. O. Box 571
Jackson, MS 39205
(601) 354-6218

ATTORNEY GENERAL
Attorney General
Carroll Gartin Building
450 High Street
P. O. Box 220
Jackson, MS 39205
(601) 354-7130

COMMERCE
Commissioner
Department of Agriculture and Commerce
1604 Walter Sillers Building
550 High Street
P. O. Box 1609 (39205)
Jackson, MS 39202
(601) 354-6563

(Continued)

Table D3 (Continued)

ECONOMIC DEVELOPMENT
Director
Mississippi Research and Development Center
3825 Ridgewood Road
P. O. Box 2470
Jackson, MS 39205
(601) 982-6456

ENVIRONMENTAL AFFAIRS
Executive Director
Air and Water Pollution Control Commission
Robert E. Lee Building
Jackson, MS 39201
(601) 354-6783

FEDERAL-STATE RELATIONS
Coordinator
Federal-State Programs
Office of the Governor
400 Watkins Building
510 George Street
Jackson, MS 39201
(601) 354-7570

FISH AND GAME
Director of Conservation
Game and Fish Commission
308 Robert E. Lee Building
P. O. Box 451 (39205)
Jackson, MS 39201
(601) 354-7333

FORESTRY
State Forester
Forestry Commission
908 Robert E. Lee Building
Jackson, MS 39201
(601) 354-7124

GEOLOGY
State Geologist and Director
Geological, Economic, and Topographical Survey
2525 N. West Street
P. O. Box 4915
Jackson, MS 39216
(601) 354-6228

(Continued)

Table D3 (Continued)

HIGHWAYS
Director
Highway Department
1004 Woolfolk State Office Building
501 N. West Street
P. O. Box 1850 (39205)
Jackson, MS 39201
(601) 354-6034

HISTORIC PRESERVATION
Director
Department of Archives and History
100 S. State Street
P. O. Box 571
Jackson, MS 39205
(601) 354-6218

LEGISLATIVE RESEARCH
Legislative Reference Librarian
Legislative Reference Bureau
P. O. Box 1040
Jackson, MS 39205
(601) 354-6165

OIL AND GAS
State Oil and Gas Supervisor
State Oil and Gas Board
1405 Woolfolk State Office Building
501 N. West Street
P. O. Box 1332 (39205)
Jackson, MS 39201
(601) 354-7104

PARKS
Executive Director
Park Commission
717 Robert E. Lee Building
Jackson, MS 39201
(601) 354-6324

PLANNING
Coordinator
Federal-State Programs
Office of the Governor
400 Watkins Building
510 George Street
Jackson, MS 39201
(601) 354-7570

(Continued)

Table D3 (Concluded)

PUBLIC WORKS
Executive Director
State Building Commission
1501 Walter Sillers Building
550 High Street
P. O. Box 2108 (39205)
Jackson, MS 39202
(601) 354-6326

SOLID WASTE MANAGEMENT
Director
Division of Solid Waste Management and Vector Control
Bureau of Environmental Health
Mississippi State Board of Health
P. O. Box 1700
Jackson, MS 39205
(601) 354-6616

WATER POLLUTION CONTROL
Executive Director
Air and Water Pollution Control Commission
Robert E. Lee Building
Jackson, MS 39201
(601) 354-6783

WATER RESOURCES
Water Engineer
Board of Water Commissioners
416 N. State Street
Jackson, MS 39201
(601) 354-7236

(Sheet 4 of 4)

Table D4

State Offices: Sources of Information Useful to Mobile District Activities Within Louisiana

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ADJUTANT GENERAL
Adjutant General
Military Department
Jackson Barracks
6400 Dauphine Street
New Orelans, LA 70146
(504) 271-6262, Ext. 201

ADMINISTRATION
Commissioner
Division of Administration
State Capitol
900 Riverside N.
Baton Rouge, LA 70804
(504) 389-2197

AUDIT
Legislative Auditor
Office of the Legislative Auditor
State Capitol
900 Riverside N.
P. O. Box 44095
Baton Rouge, LA 70804
(504) 389-5466

BANKING
Commissioner of Financial Institutions
State Banking Department
802 All American Building
5700 Florida Blvd.
P. O. Box 44095, Capitol Sta.
Baton Rouge, LA 70806
(504) 389-7639

AGRICULTURE
Commissioner
Department of Agriculture
State Capitol
900 Riverside N.
P. O. Box 44302, Capitol Sta.
Baton Rouge, LA 70804
(504) 389-5453

(Continued)

Table D4 (Continued)

AIR POLLUTION CONTROL
Chief
Air Quality Section
Bureau of Environmental Services
Health and Human Resources Administration
414 State Office Building
325 Loyola Avenue
P. O. Box 60603 (70160)
New Orleans, LA 70112
(504) 527-5115

ARCHIVES AND RECORDS
Director
Archives and Records Division
Office of the Secretary of State
1515 Choctaw Drive
P. O. Box 44125
Baton Rouge, LA 70804
(504) 389-5256

ATTORNEY GENERAL
Attorney General
Department of Justice
State Capitol
900 Riverside N.
Baton Rouge, LA 70804
(504) 389-6761

COMMERCE
Executive Director
Department of Commerce and Industry
State Land and Natural Resources Building
P. O. Box 44185, Capitol Sta.
Baton Rouge, LA 70804
(504) 389-5371

ECONOMIC DEVELOPMENT
Executive Director
Department of Commerce and Industry
State Land and Natural Resources Building
P. O. Box 44185, Capitol Sta.
Baton Rouge, LA 70804
(504) 389-5371

(Continued)

Table D4 (Continued)

ENVIRONMENTAL AFFAIRS
Executive Director
Governor's Council on Environmental Quality
P. O. Box 44066
Baton Rouge, LA 70804
(504) 389-6981

FEDERAL-STATE RELATIONS
Director
Commission on Intergovernmental Relations
300 Louisiana Avenue
Baton Rouge, LA 70802
(504) 389-5664

FISH AND GAME
Director
Wildlife and Fisheries Commission
400 Royal Street
New Orelans, LA 70130
(504) 568-5667

FORESTRY
State Forester
Forestry Commission
P. O. Box 1628
Baton Rouge, LA 70821
(504) 389-7361

GEOLOGY
State Geologist
Louisiana Geological Survey
Department of Conservation
Geology Building
Louisiana State University
Box G, University Sta.
Baton Rouge, LA 70893
(504) 389-5812

HIGHWAYS
Director
Department of Highway
1201 Capitol Access Road
P. O. Box 44245, Capitol Sta.
Baton Rouge, LA 70804
(504) 389-5112

(Continued)

Table D4 (Continued)

HISTORIC PRESERVATION
Director
Art, Historical, and Cultural Preservation Agency
Old State Capitol
100 St. Philip Street
Baton Rouge, LA 70801
(504) 389-5086

LAW ENFORCEMENT PLANNING
Executive Director
Commission on Law Enforcement and Administration of Criminal Justice
1885 Wooddale Blvd.
Baton Rouge, LA 70806
(504) 389-7178

LEGISLATIVE RESEARCH
Executive Director
Legislative Council
State Capitol
900 Riverside N.
P. O. Box 44012, Capitol Sta.
Baton Rouge, LA 70804
(504) 389-6141

LIBRARY SERVICES
State Librarian
State Library
760 Riverside N.
P. O. Box 131
Baton Rouge, LA 70821
(504) 389-5156

NATURAL RESOURCES
Commissioner
Department of Conservation
State Land and Natural Resources Building
P. O. Box 44275
Baton Rouge, LA 70804
(504) 389-5161

OIL AND GAS
Oil and Gas Division
Land Office
State Land and Natural Resources Building
Baton Rouge, LA 70804
(504) 389-5184

(Continued)

Table D4 (Continued)

PARKS

Director
State Parks and Recreation Commission
625 N. 4th Street
P. O. Drawer 1111 (70821)
Baton Rouge, LA 70802
(504) 389-5761

PLANNING

Executive Director
State Planning Office
4528 Bennington Avenue
Baton Rouge, LA 70808
(504) 389-7041

POLICE

Superintendent
State Police Division
Department of Public Safety
265 S. Foster Drive
P. O. Box 1791
Baton Rouge, LA 70821
(504) 389-7406

PUBLIC UTILITIES

Secretary
Public Service Commission
State Capitol
900 Riverside N.
P. O. Box 44035, Capitol Sta.
Baton Rouge, LA 70804
(504) 389-5867

PUBLIC WORKS

Director
Department of Public Works
Capitol Annex
Baton Rouge, LA 70804
(504) 389-6287

SECRETARY OF STATE

Secretary of State
State Capitol
900 Riverside N.
P. O. Box 44125
Baton Rouge, LA 70804
(504) 389-6181

(Continued)

Table D4 (Concluded)

WATER POLLUTION CONTROL
Director
Water Pollution Control Division
Wildlife and Fisheries Commission
Geology Building
Louisiana State University
Baton Rouge, LA 70803
(504) 389-5300

Table D5

State Offices: Sources of Information Useful to
Mobile District Activities Within Georgia

ADJUTANT GENERAL
Adjutant General
Department of Defense
959 E. Confederate Avenue, S.E.
P. O. Box 17965
Atlanta, GA 30316
(404) 656-1700

ADMINISTRATION
Commissioner
Department of Administrative Services
400 Mitchell-Pryor Building
116 Mitchell Street, S.W.
Atlanta, GA 30303
(404) 656-5514

AGRICULTURE
Commissioner
Department of Agriculture
Agriculture Building
Capitol Sq., S.W.
Atlanta, GA 30334
(404) 656-3600

AIR POLLUTION CONTROL
Chief
Air Protection Branch
Environmental Protection Division
Department of Natural Resources
Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-6900

ARCHIVES AND RECORDS
Director
Department of Archives and History
Office of the Secretary of State
330 Capitol Avenue, S.E.
Atlanta, GA 30334
(404) 656-2358

(Continued)

ATTORNEY GENERAL
Attorney General
Law Department
132 Judicial Building
40 Capitol Sq., S.W.
Atlanta, GA 30334
(404) 656-4586

COMMERCE
Commissioner
Bureau of Industry and Trade
Department of Community Development
601 Trinity-Washington Building
270 Washington Street, S.W.
P. O. Box 38097
Atlanta, GA 30334
(404) 656-3556

COMMUNITY AFFAIRS
Commissioner
Bureau of Community Affairs
Department of Community Development
7 Martin Luther King, Jr., Dr., S.W.
Atlanta, GA 30334
(404) 656-3836

ECONOMIC DEVELOPMENT
Commissioner
Bureau of Industry and Trade
Department of Community Development
601 Trinity-Washington Building
270 Washington Street, S.W.
P. O. Box 38097
Atlanta, GA 30334
(404) 656-3556

ENVIRONMENTAL AFFAIRS
Director
Environmental Protection Division
Department of Natural Resources
822 Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-4713

(Continued)

Table D5 (Continued)

FISH AND GAME
Director
Game and Fish Division
Department of Natural Resources
719 Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-3523

FORESTRY
Director
Forestry Commission
P. O. Box 819
Macon, GA 31202
(912) 744-3237

GEOLOGY
Director
Geologic and Water Resources Division
Department of Natural Resources
400 Agriculture Building
19 Martin Luther King, Jr., Dr., S.W.
Atlanta, GA 30334
(404) 656-3214

HIGHWAYS
State Highway Engineer and Commissioner
Department of Transportation
2 Capitol Sq., S.W.
Atlanta, GA 30334
(404) 656-5206

HISTORIC PRESERVATION
Chief
Historic Preservation Section
Department of Natural Resources
703-C Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-2840

LAW ENFORCEMENT PLANNING
Administrator
State Crime Commission
1430 W. Peachtree St., N.W.
Atlanta, GA 30309
(404) 656-3825

(Continued)

Table D5 (Continued)

LEGISLATIVE RESEARCH
Legislative Counsel
316 State Capitol
Atlanta, GA 30334
(404) 656-5000

LIBRARY SERVICES
Director
Division of Public Library Services
Department of Education
156 Trinity Avenue, S.W.
Atlanta, GA 30303
(404) 656-2461

MINING
Director
Geologic and Water Resources Division
Department of Natural Resources
400 Agriculture Building
19 Martin Luther King, Jr., Dr., S.W.
Atlanta, GA 30334
(404) 656-3214

NATURAL RESOURCES
Commissioner
Department of Natural Resources
815 Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-3500

PARKS
Director
Division of Parks and Historic Sites
Department of Natural Resources
707D Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-2753

PLANNING
Director
Office of Planning and Budget
611C Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-3820

(Continued)

Table D5 (Continued)

POLICE
Commanding Officer
State Patrol
Department of Public Safety
959 E. Confederate Avenue, S.E.
Atlanta, GA 30316
(404) 656-6082

PUBLIC UTILITIES
Executive Secretary
Public Service Commission
162 New State Office Building
244 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-4536

PUBLIC WORKS
Director
Building Authority
700 Health Building
47 Trinity Avenue, S.W.
Atlanta, GA 30334
(404) 656-3250

SECRETARY OF STATE
Secretary of State
214 State Capitol
Atlanta, GA 30334
(404) 656-2881

SOLID WASTE MANAGEMENT
Chief
Solid Waste Management Section
Environmental Protection Division
Department of Natural Resources
Trinity-Washington Building
270 Washington Street, S.W.
Atlanta, GA 30334
(404) 656-2833

STATE-LOCAL RELATIONS
Commissioner
Bureau of Community Affairs
Department of Community Development
7 Martin Luther King, Jr., Dr., S.W.
Atlanta, GA 30334
(404) 656-3836

(Continued)

Table D5 (Concluded)

TRANSPORTATION	
	Commissioner Department of Transportation 2 Capitol Sq., S.W. Atlanta, GA 30334 (404) 656-5206
WATER POLLUTION CONTROL	
	Chief Water Protection Branch Environmental Protection Division Department of Natural Resources Trinity-Washington Building 270 Washington Street, S.W. Atlanta, GA 30334 (404) 656-6593
WATER RESOURCES	
	Director Geologic and Water Resources Division Department of Natural Resources 400 Agriculture Building 19 Martin Luther King, Jr., Dr., S.W. Atlanta, GA 30334 (404) 656-3214

APPENDIX E: A PHOTOINTERPRETERS' CATALOG OF REGULATED ACTIVITIES

Introduction

Background

1. The study reported in the main text of this report was conducted to determine procedures for detecting and monitoring activities regulated by the Mobile District. Procedures using digital scanner systems and aerial photographic systems were described in Parts III and IV, respectively. Part V applies these procedures to selected regulated activities within the District. One of the applications utilizing aerial photographic procedures was the detection and monitoring of regulated structures and activities falling under the purviews of Section 10 of the River and Harbor Act and Section 404 of the Federal Water Pollution Control Act.

2. A critical requirement to successful application of aerial photographic procedures is that the photointerpreter be very familiar with ground truth information in the vicinity or region of the aerial photography. A common and direct way of obtaining this information is by on-site field inspections of many example activities. This method of familiarization is frequently impractical from a managerial point of view due to time and budgetary constraints. Also, inexperienced personnel would have to be cycled through identical field experiences in order to develop adequate and similar interpretation skills.

3. A more practical approach to the problem would be to develop a photointerpreters' catalog of sample activities that could be used in-house without resorting to field trips. This document could then be passed from one employee to another as personnel changes are made. This not only is more fiscally conservative but also ensures greater uniformity and consistency in the interpreted photography.

Objective and scope

4. The objective of this appendix is to present a catalog of sample activities regulated by the Mobile District. Its intended use is to

provide the Regulatory Functions Branch of the Mobile District with an aid for photointerpreting aerial photography. It is meant to provide photointerpreters with a set of photointerpretation keys or training samples of regulated activities along and near the Gulf Coastal region of the Mobile District. With this catalog, one with little or no background experience in interpreting aerial photography should be able to develop sufficient skills to interpret aerial photography taken in these regions of the Mobile District. The examples selected for inclusion in the catalog are activities that comprise the majority of the Mobile District's permit-processing work load during a normal year.

The Photointerpreters' Catalog

5. The catalog begins with a demonstration of altitude effects on aerial photography (pages E5 and E6). As a subject or feature of interest, a pier with several extensions was chosen. Starting with the highest altitude, the pier is shown at successively lower and lower altitudes. From this demonstration, one can readily see the changes in scale and detail as a function of altitude.

6. The remainder of the catalog contains pictures and diagrams of those activities that compose the majority of the Mobile District's permit-processing work load during a normal year. To demonstrate the variability of the activities, several examples of each type are presented. Each example selected for presentation in the catalog was assembled according to a fixed format, which is described in the following paragraphs.

7. First, a brief description is given. This description is worded in much the same way as it might appear on a permit form. Following the descriptive paragraph is a schematic drawing of the activity.

8. The next two entries in the catalog are the aerial photographs. One set of photographs is in color and the other is in black and white. The original color photography (flown in March 1977) was taken in flight with Kodak Aerochrome Infrared film number 2443 using a Wratten filter number 12. The black and white photography (flown in August 1976) was

taken with Kodak Plus-X Aerographic film 2402 using a Wratten filter number 12. Both the black and white Aerographic and the color infrared films were flown at an altitude of 12,000 ft. Since the cameras used had 6-in. focal lengths, this translates into a scale of 1:24,000.

9. The aerial photography is presented first by a print made from the original film at the original scale; then an enlargement of the area of interest is presented. The scale of the enlargements is approximately 1:6,000. The grainy appearance of the black and white enlargements is a result of the quality of the original imagery. When viewed with a magnification factor of 10, the original film shows an innate graininess. In most cases, however, this does not detract from the intended purpose of the catalog.

10. After the aerial photographic entries, ground photographs from several vantage points around the feature of interest are presented. These shots were taken with 35mm cameras using Kodak Kodacolor and Ektachrome film. The date of the ground photography is March 1978.

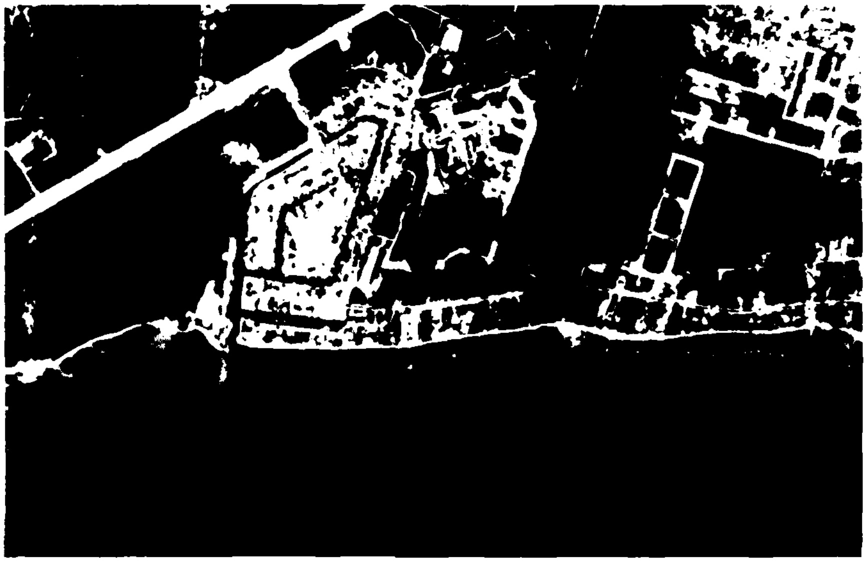
11. Finally, for each example in the catalog there is a table of film/filter combinations that can be used to optimize the selection of a film and filter. These tables were generated by using the WES-developed Photographic Systems Simulation Model (see Appendix C). The filters used in the model are the Wratten Nos. 12, 47B, 58, 25A, 87C, and 89B. The types of film used are described in the following tabulation.

Film No.	Description
2402	Kodak Plus-X Aerographic (black and white)
2403	Kodak Tri-X Panchromatic (black and white)
2448	Kodak Ektachrome MS Aerographic (color)
2443	Kodak Aerochrome Infrared (color)
2424	Kodak Infrared Aerographic (black and white)

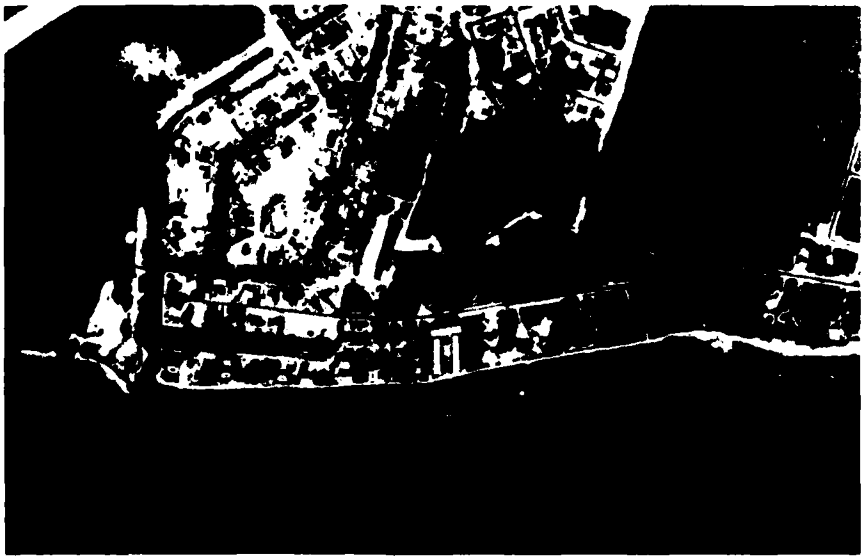
12. In each table, the four best film/filter combinations are ranked and given a priority number according to their contrast index number (Appendix C). The larger the value of the index, the higher the priority.

13. The tables also contain the actual contrast index value for each film/filter combination. Stated briefly, the contrast index is a measure of the optical film density difference between the feature and background. The higher the index, the greater is the probability of detection. A contrast index of 0.20 has been determined as the threshold value for the human eye. Below 0.20, the photointerpreter cannot distinguish between background and feature. For values equal to or greater than 0.20, the features can be distinguished from the backgrounds.

EFFECTS OF ALTITUDE
ON PIER WITH EXTENSIONS



Feature Area Flown at 12,000 feet
(Scale = 1:24,000)



Feature Area Flown at 7,000 feet
(Scale = 1:14,000)

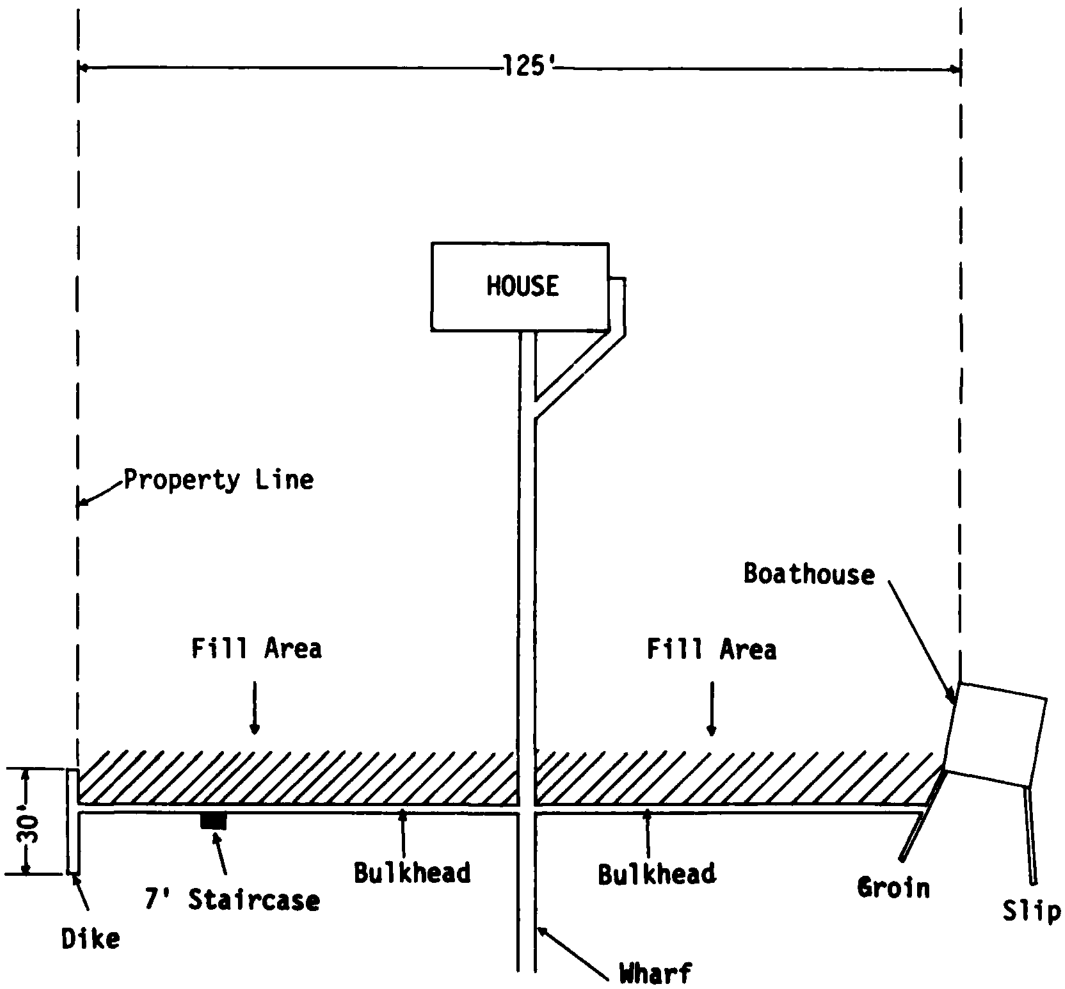
Feature Area Flown at 4,000 feet
(Scale = 1:8,000)

Feature Area Flown at 2,000 feet
(Scale = 1:4,000)

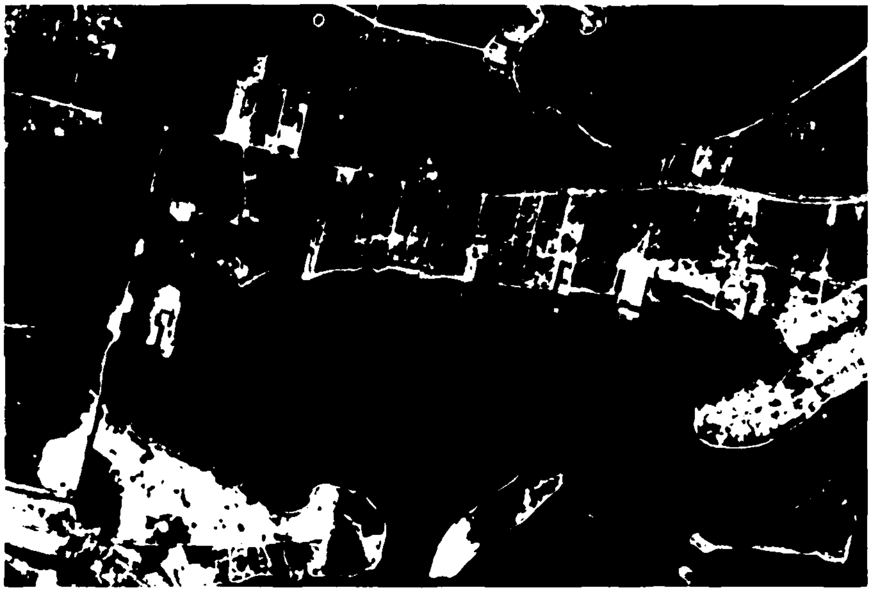
TIMBER BULKHEAD

DESCRIPTION: A timber bulkhead 125 ft in length with approximately 250 cu yd of sand-loam fill from upland sources behind bulkhead. In addition a 30-ft-long timber dike and 7-ft-wide wooden stairway adjacent to bulkhead

ILLUSTRATION:



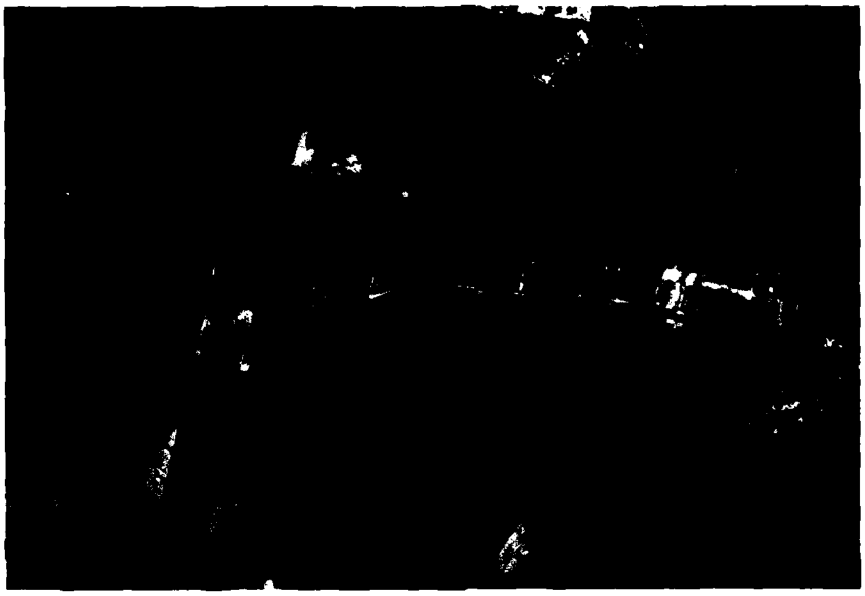
COLOR INFRARED AERIAL PHOTOGRAPHY



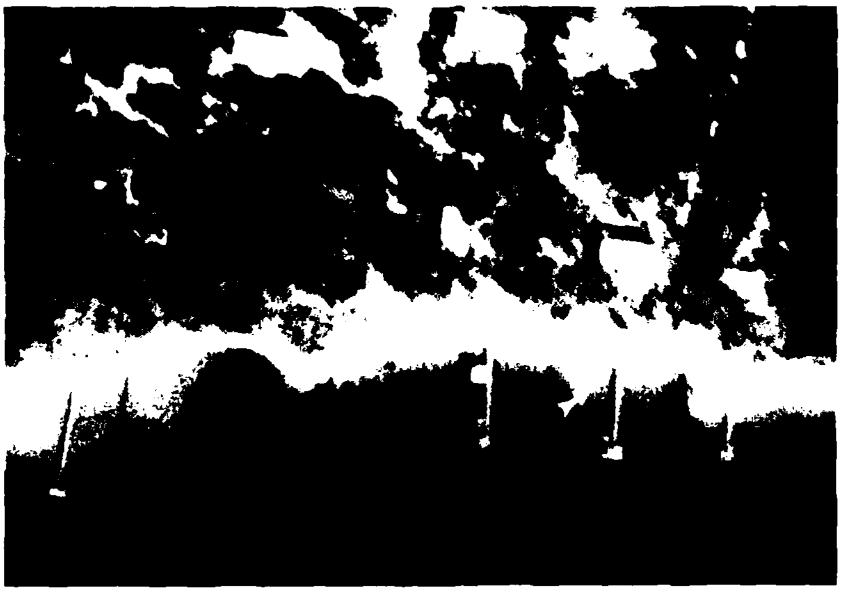
Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

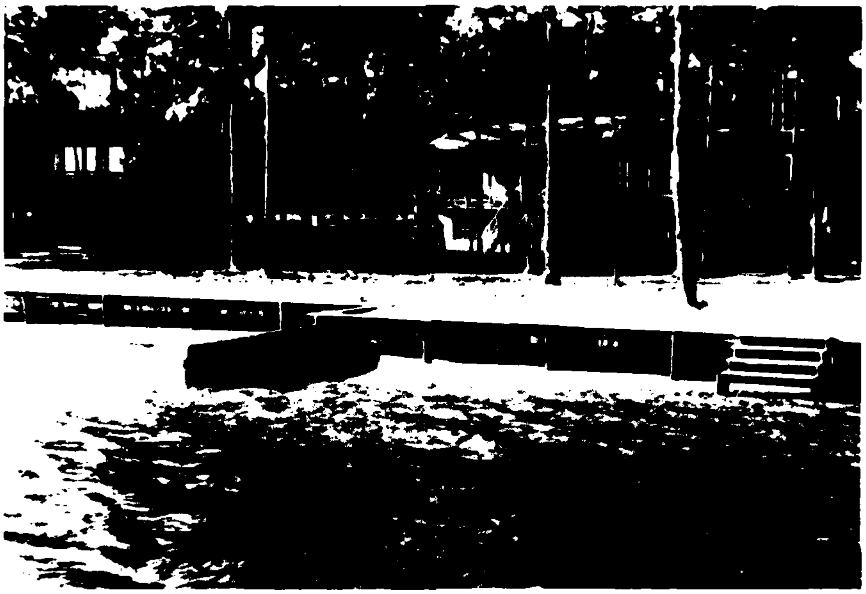


Feature Area at a Scale of 1:24,000

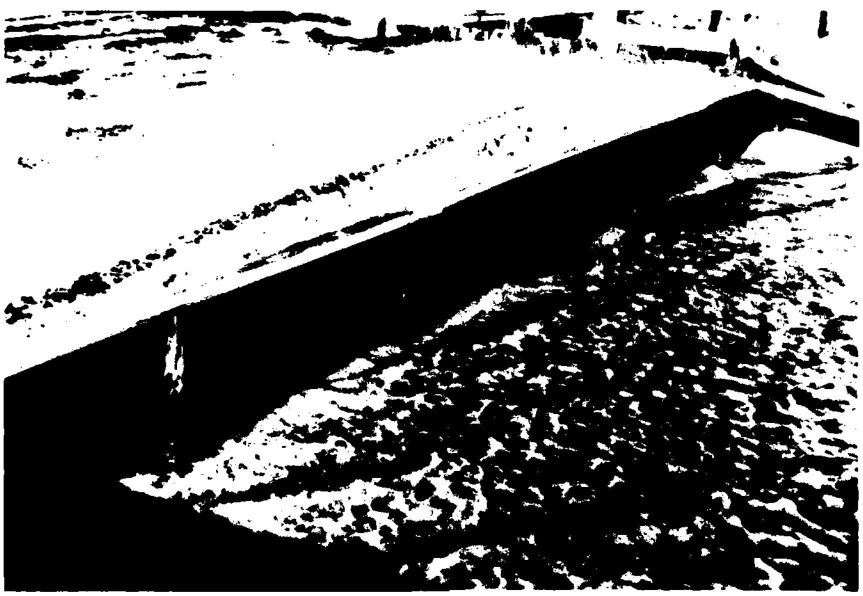


Enlargement of Feature Area

GROUND PHOTOGRAPHY



Timber Bulkhead with Stairway and Dike



Section of Bulkhead near Boat Slip

OPTIMUM FILM/FILTER COMBINATIONS

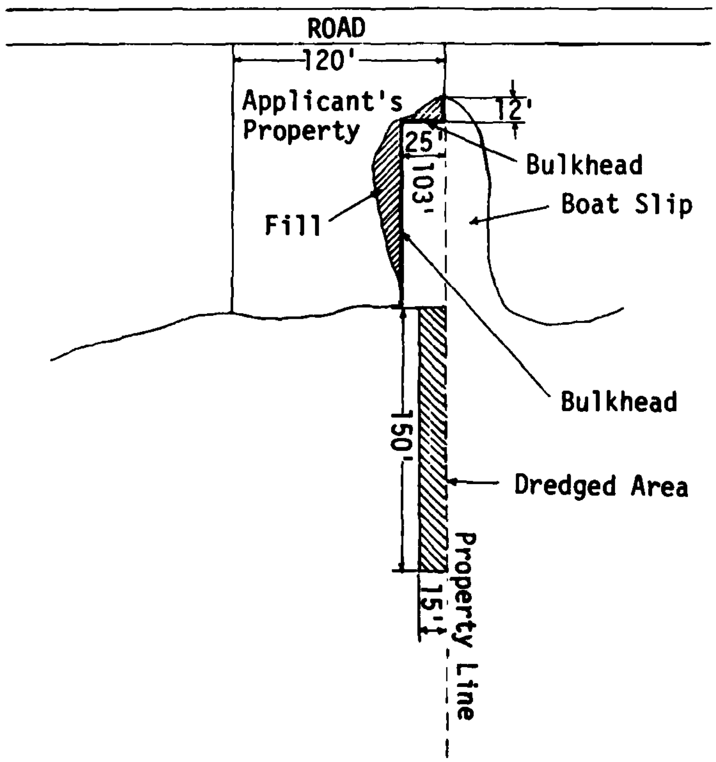
Feature: Beach Sand
Background: Water less than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	2.66
2	2443	12	2.61
3	2448	3	2.60
4	2424	87C	1.03

BULKHEAD

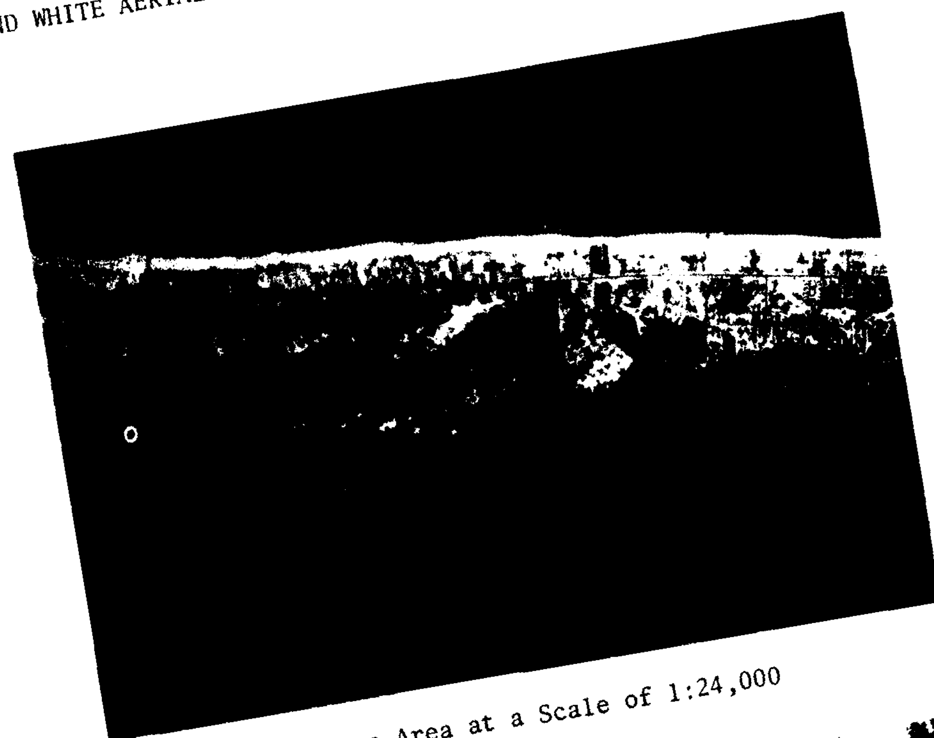
DESCRIPTION: A timber bulkhead with a total length of approximately 140 ft surrounding a boat slip. Approximately 300 cu yd of material removed by dragline from mouth of boat slip and used as backfill behind bulkhead

ILLUSTRATION:



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

View of Bulkhead Toward Mouth of Slip

Interior of Boat Slip with Permitted Bulkhead at Left

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Beach Sand
Background: Water less than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	2.66
2	2443	12	2.61
3	2448	3	2.60
4	2424	87C	1.03

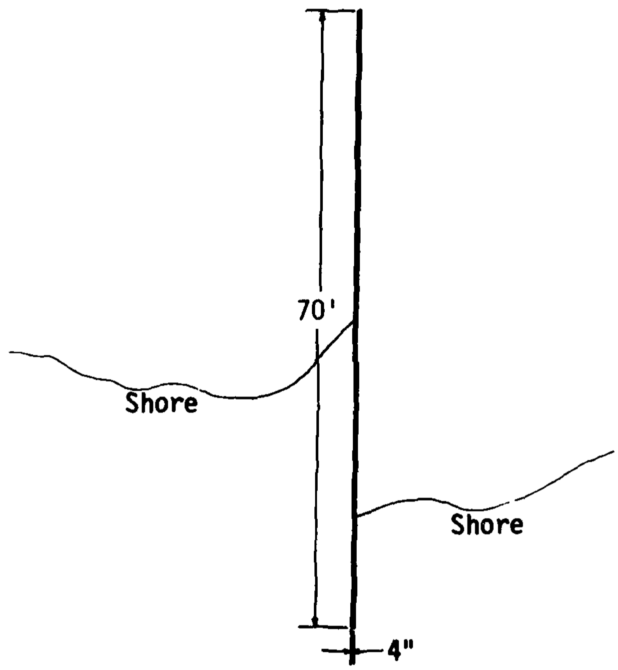
Feature: Grass
Background: Water less than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	12	0.65
2	2448	3	0.57
3	2424	87C	0.57
4	2443	3	0.54

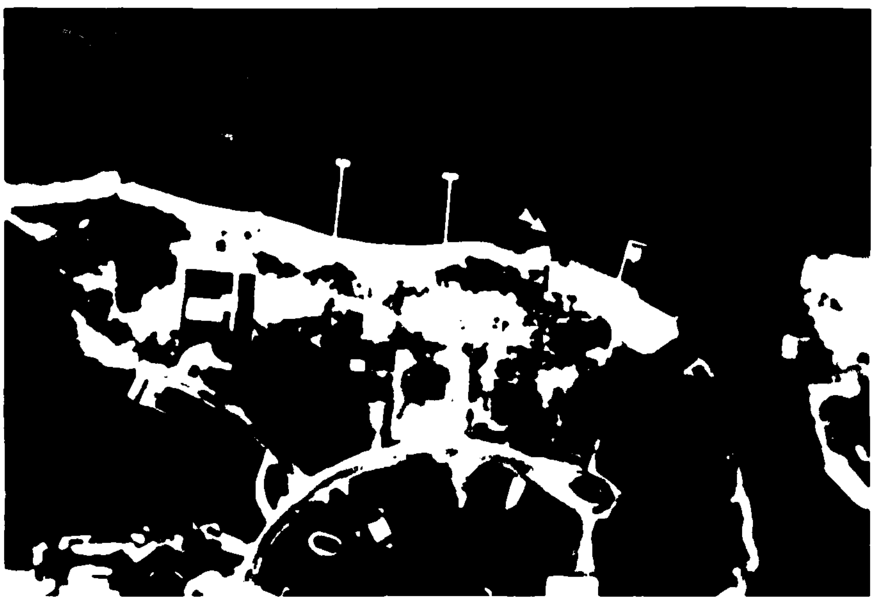
WOODEN DIKE

DESCRIPTION: A wooden dike 70 ft long, 3 ft high, and 4 in. thick, constructed of creosoted wooden planks and pilings

ILLUSTRATION:



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Dike Constructed of Creosoted Wooden Planks and Pilings

OPTIMUM FILM/FILTER COMBINATIONS

The dike presented in this example offers only its narrowest dimension (i.e. its thickness) for detection during vertical overflights. Its 4-in. thickness is not resolvable with either the black and white or color film types flown for this catalog (see Part IV in the main text). The upper limit at which a 4-in. thickness is still detectable on these types of film is approximately 200 ft. At higher altitudes, one must determine the existence of dikes by inferential methods. For example, the fact that the dike tends to impede the movement of shifting sand along the shore frequently causes water depths to be different on either side of the dike. The selection of an optimum film/filter combination would then be based upon differences in water

depth rather than differences in the dike and water. In the present example, one can easily detect the differences in water depth. Therefore, the following table of optimum film/filter combinations was generated using two water depths.

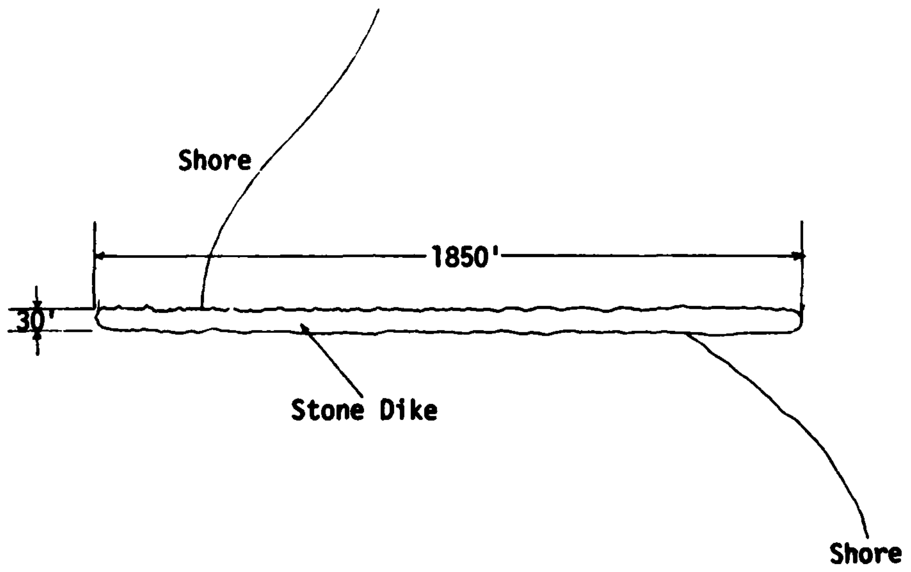
Feature: Water less than 0.5 yd in depth
Background: Water less than 1.0 yd but greater than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	0.67
2	2443	3	0.50
3	2443	12	0.48
4	2402	58	0.22

STONE DIKE

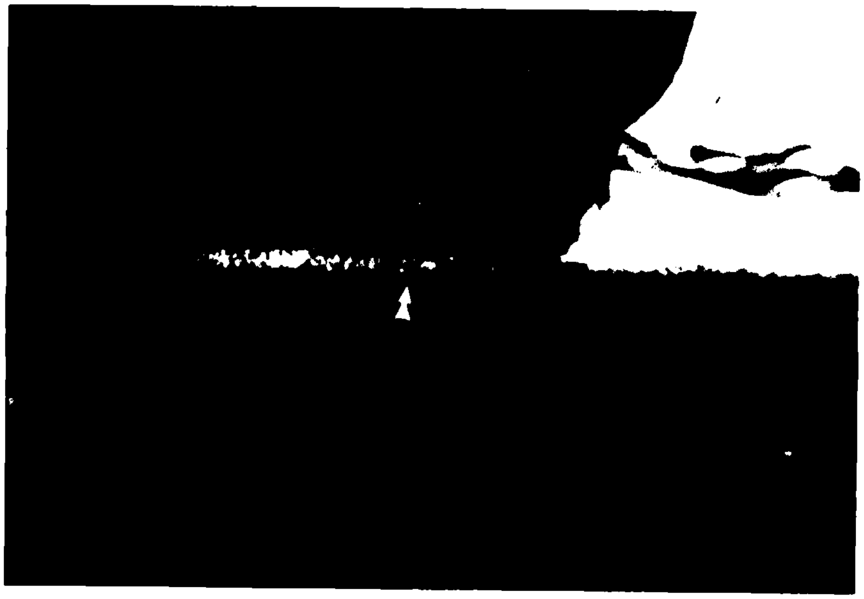
DESCRIPTION: A stone dike approximately 30 ft wide by 1850 ft long

ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY

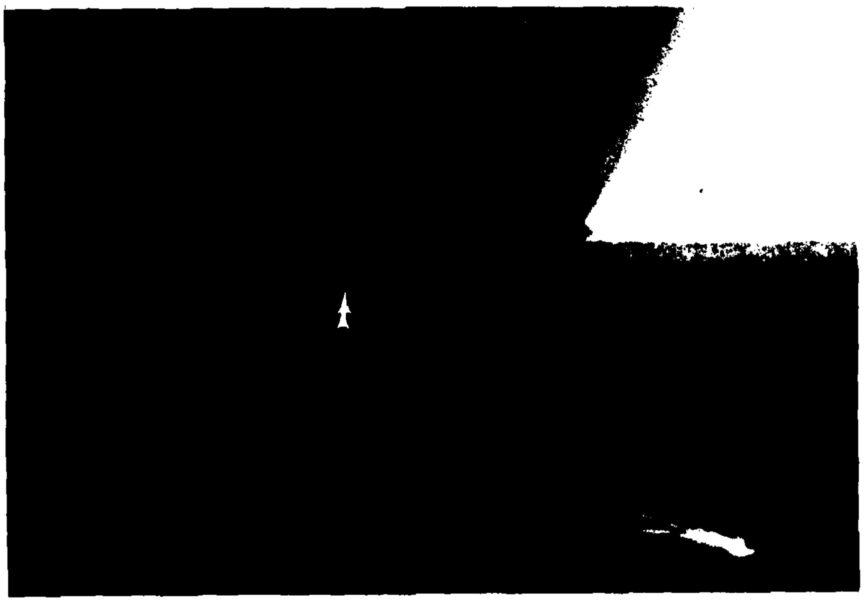
Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

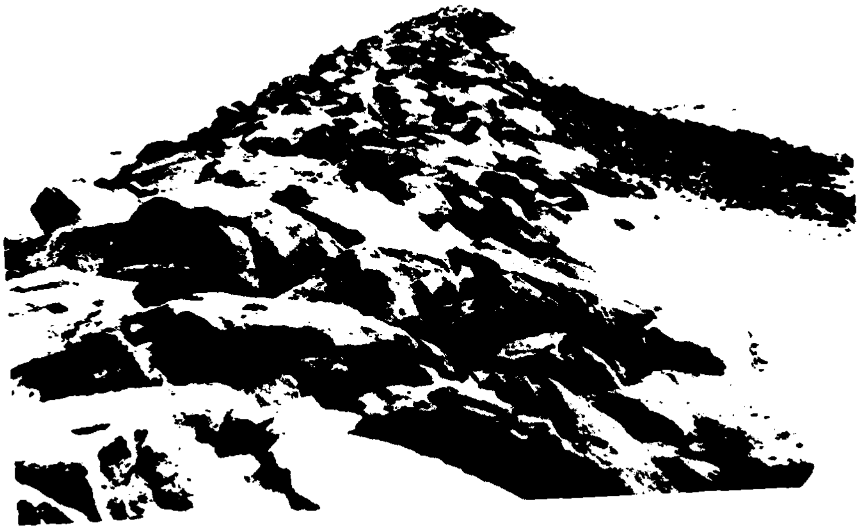
BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

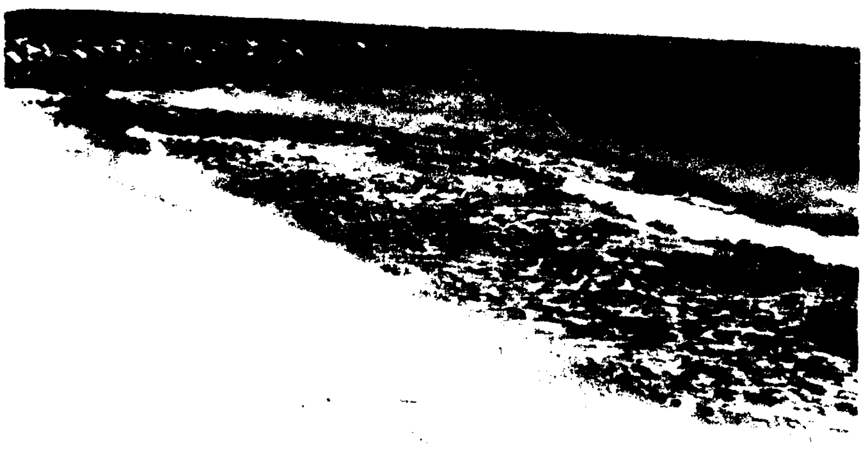
GROUND PHOTOGRAPHY



Lengthwise View of Dike

Section of Dike Bordering Shore

Close-Up of Boulders Composing Dike



Side View of Dike

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Stone*
Background: Water greater than 1.0 yd in depth

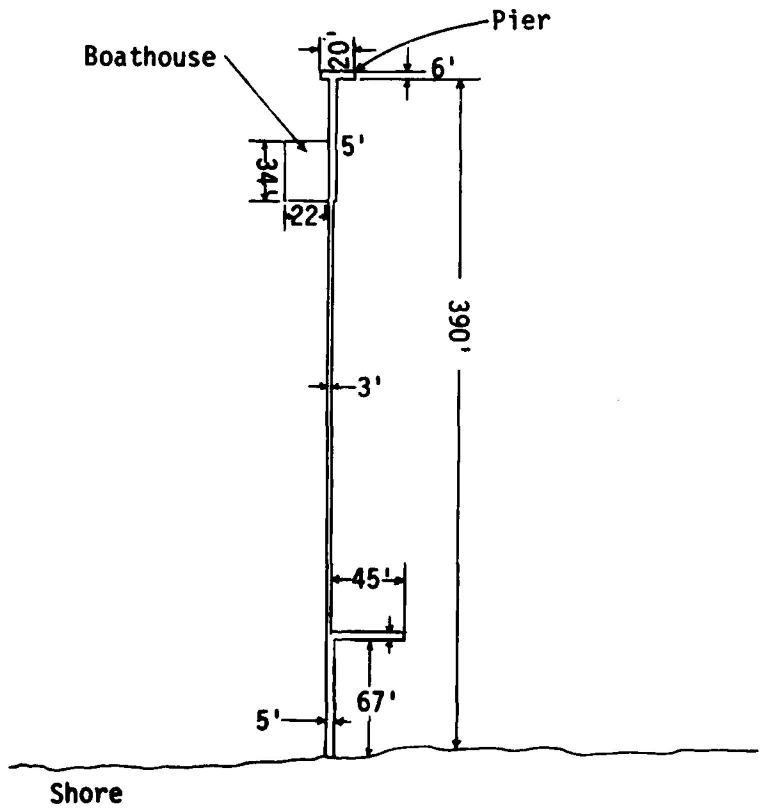
Priority	Film	Filter	Contrast Index
1	2443	3	1.06
2	2443	12	1.06
3	2448	3	0.99
4	2424	87C	0.43

*This feature is not listed in the feature/background matrices (Appendix C), the reflectance signature was obtained from data tapes and the feature's contrast index values were calculated.

METAL BOATHOUSE

DESCRIPTION: A metal boathouse 22 ft wide by 34 ft long adjacent to a pier 390 ft long with a 6 by 20 ft "T" on the outboard and an extension 5 by 45 ft located 67 ft from shore. The width of the pier varies from 3 to 5 ft

ILLUSTRATION:



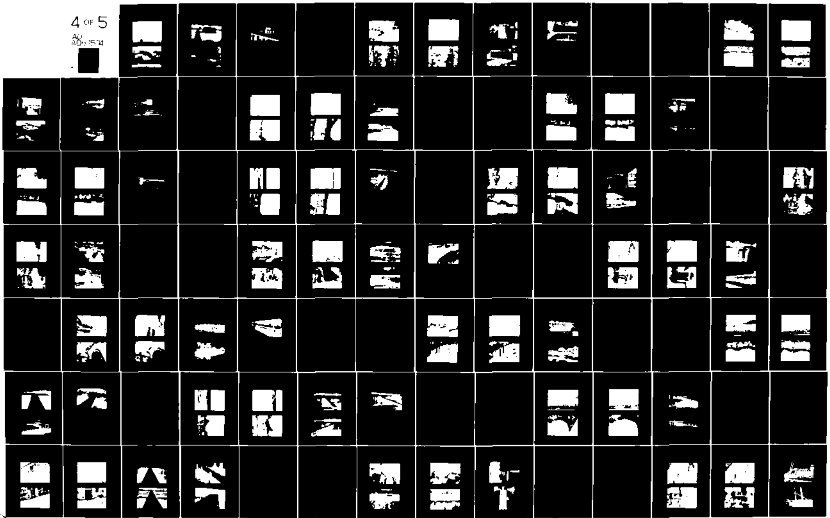
COLOR INFRARED AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

AD-A087 584 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 14/5
REMOTE-SENSING PROCEDURES FOR DETECTING AND MONITORING VARIOUS --ETC(U)
APR 80 H STRUVE, W L KIRK
UNCLASSIFIED WES/TR/EL-80-1 NL

4 of 5

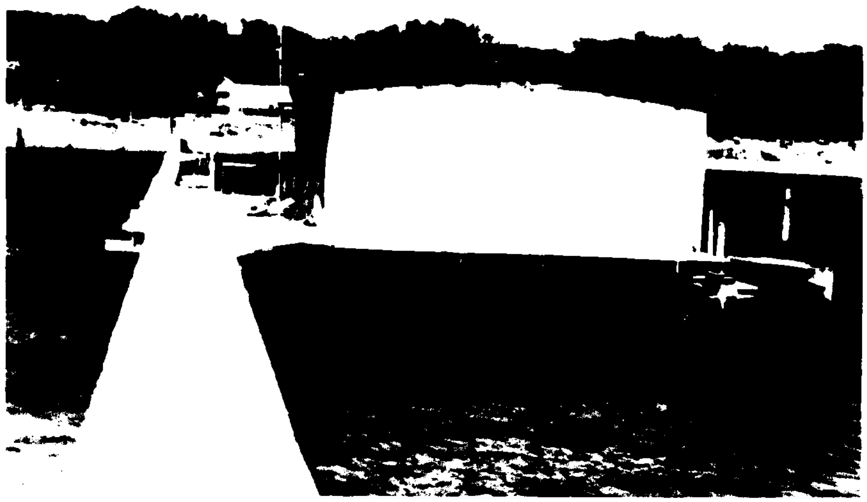


BLACK AND WHITE AERIAL PHOTOGRAPHY

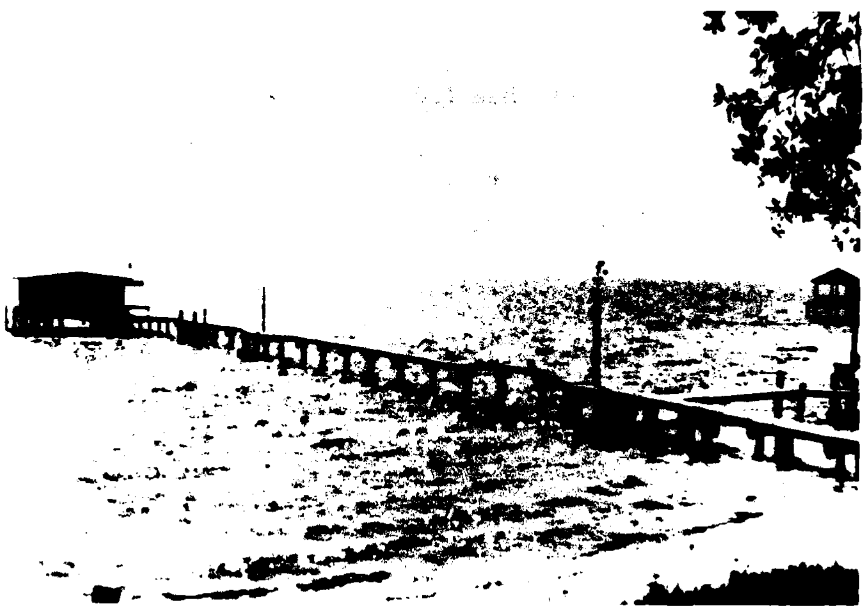
Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

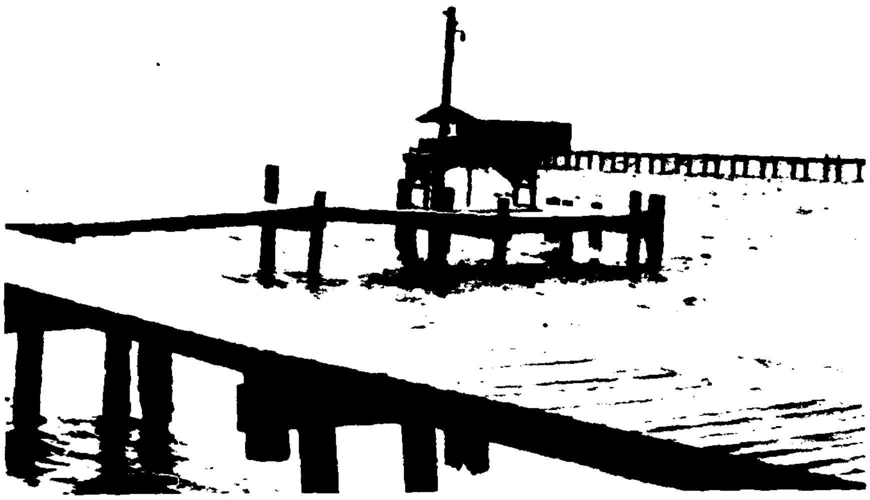
GROUND PHOTOGRAPHY



Rear View of Metal Boathouse



Boathouse and Adjoining Pier



Extension of Pier Used as Identifying Feature

OPTIMUM FILM/FILTER COMBINATIONS

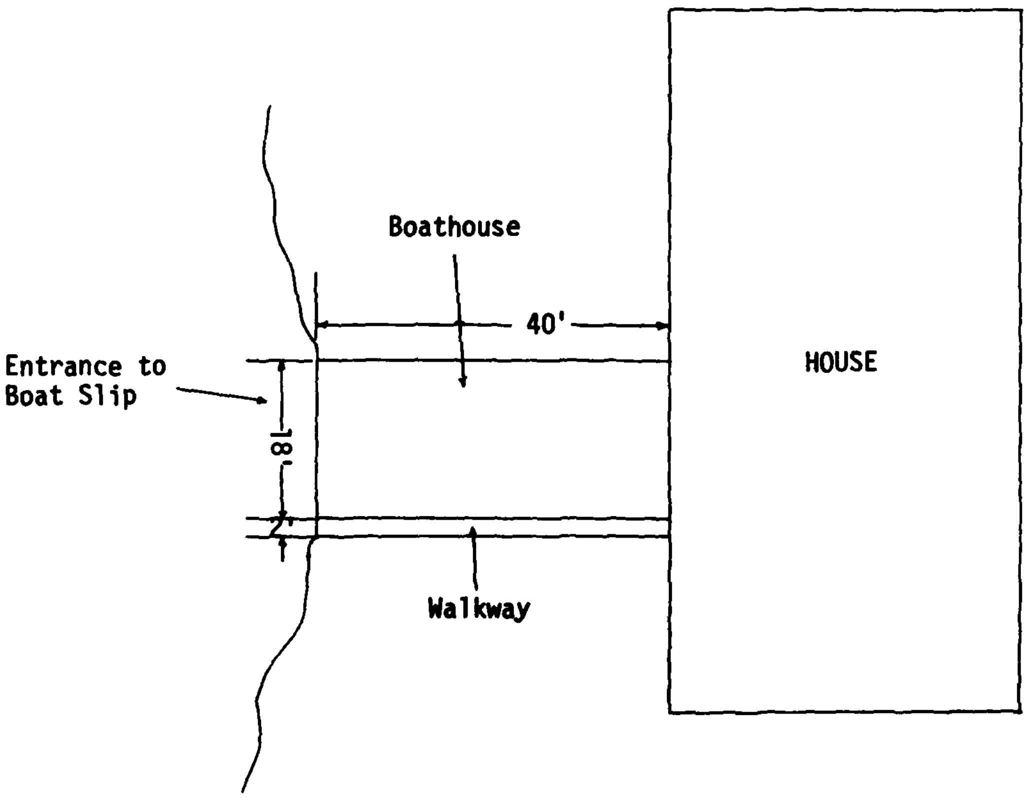
Feature: Metal Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	1.92
2	2443	3	1.80
3	2443	12	1.68
4	2402	47B	0.68

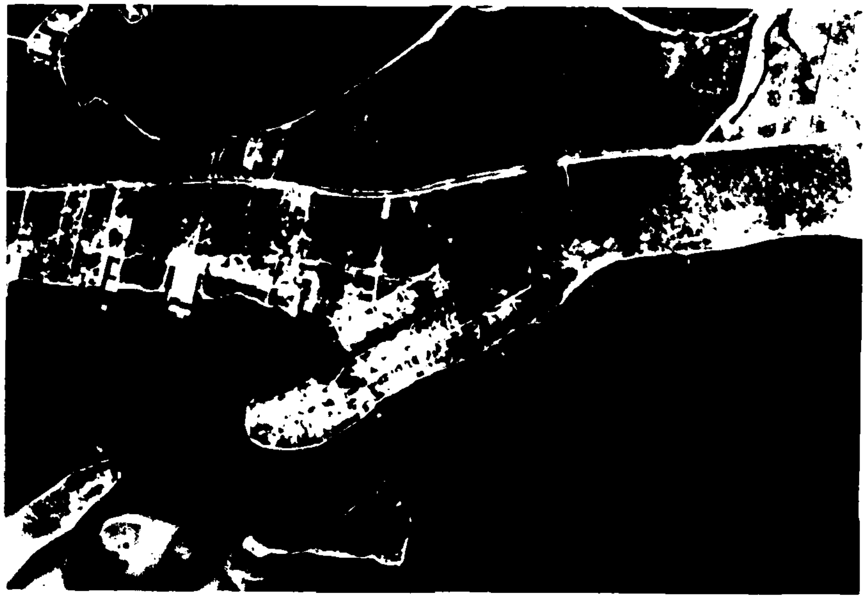
BOATHOUSE ADJACENT TO RESORT HOME

DESCRIPTION: A covered boathouse 18 ft wide by 40 ft long with a 2-ft-wide by 40-ft-long creosoted timber walkway

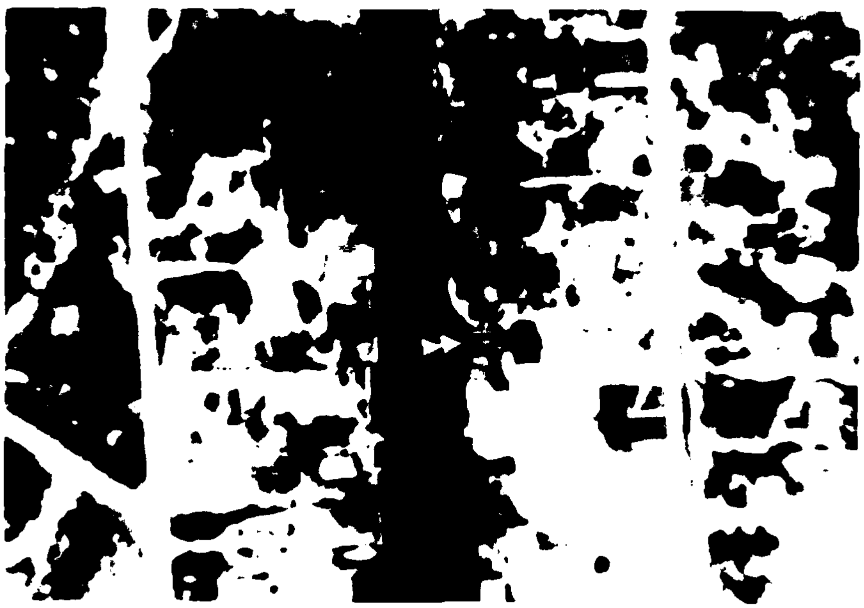
ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

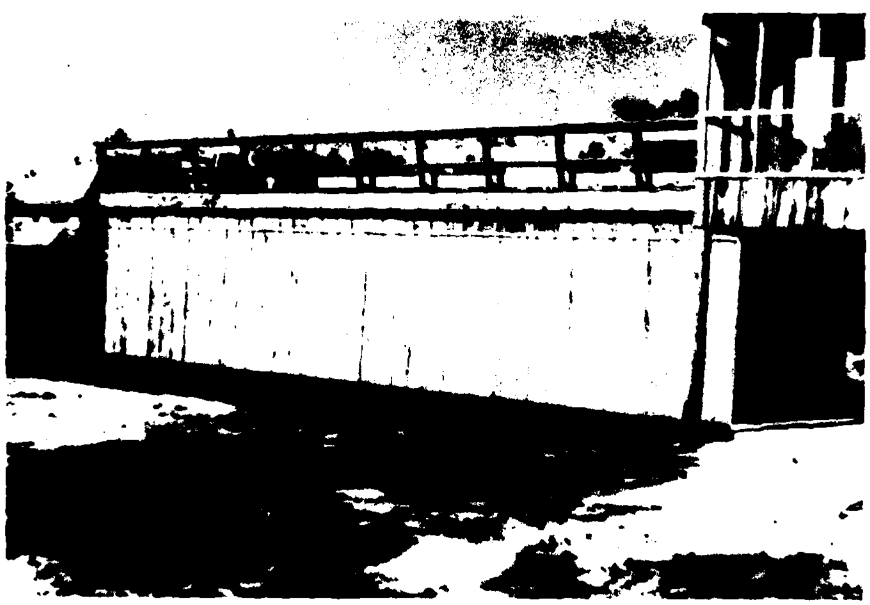
BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

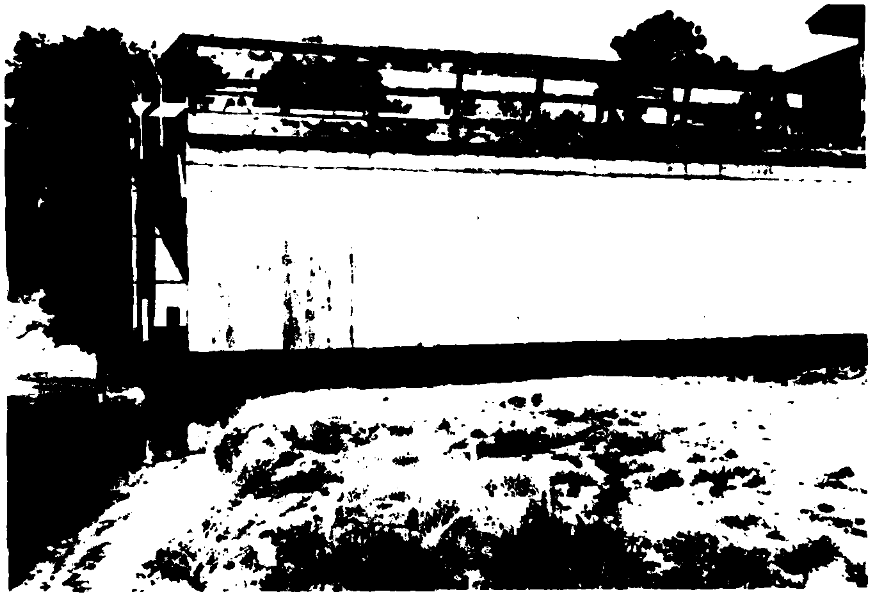
Enlargement of Feature Area

GROUND PHOTOGRAPHY

Open End of Boathouse Facing Cove



Intersection of Home and Boathouse



Side View of Boathouse

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Wooden Structure
Background: Grass

Priority	Film	Filter	Contrast Index
1	2448	3	0.44
2	2443	12	0.34
3	2443	3	0.29
4	2424	87C	0.25

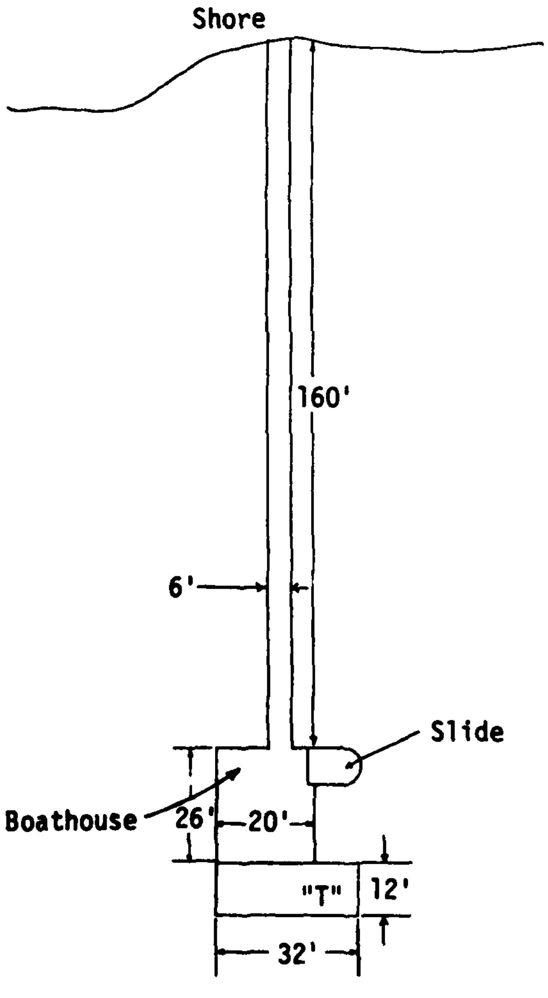
Feature: Wooden Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

FIBERGLASS BOATHOUSE

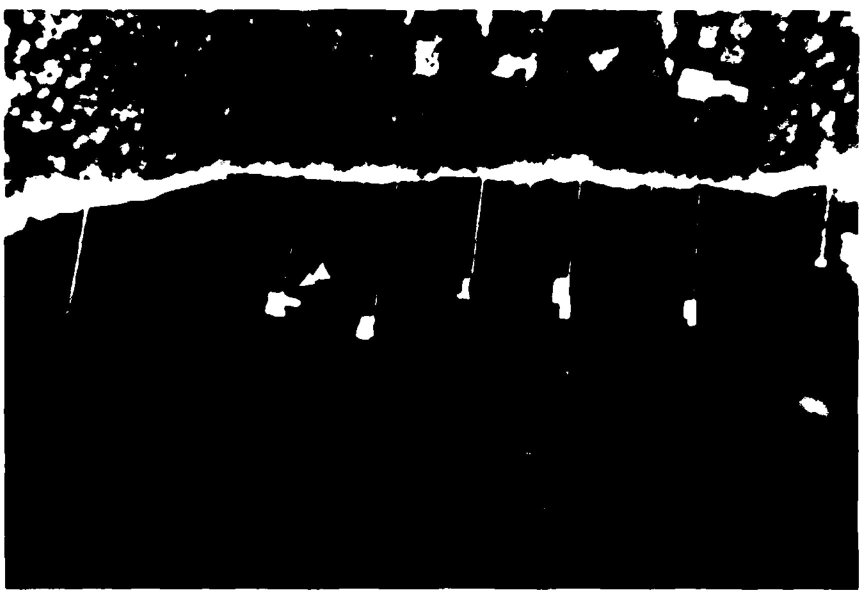
DESCRIPTION: A fiberglass boathouse 26 ft long by 20 ft wide constructed adjacent to a pier 6 ft wide and 160 ft long with a 12- by 32-ft "T" on the outboard end

ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000



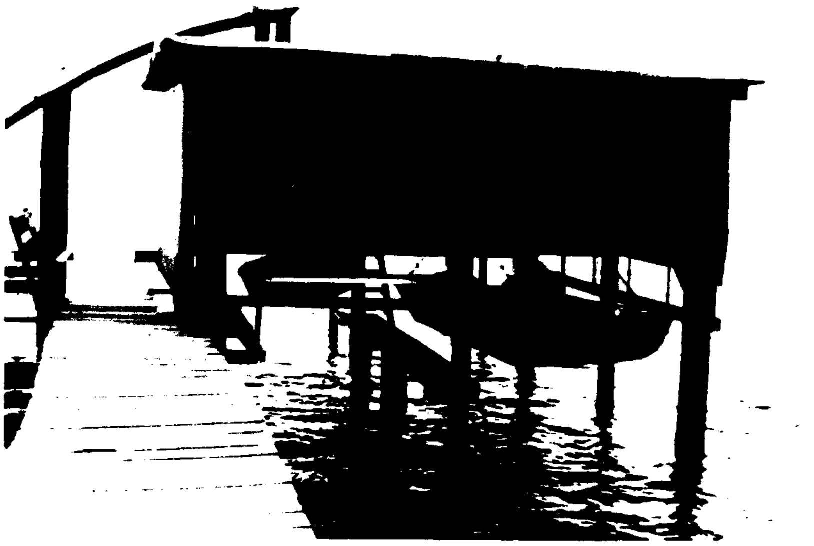
Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

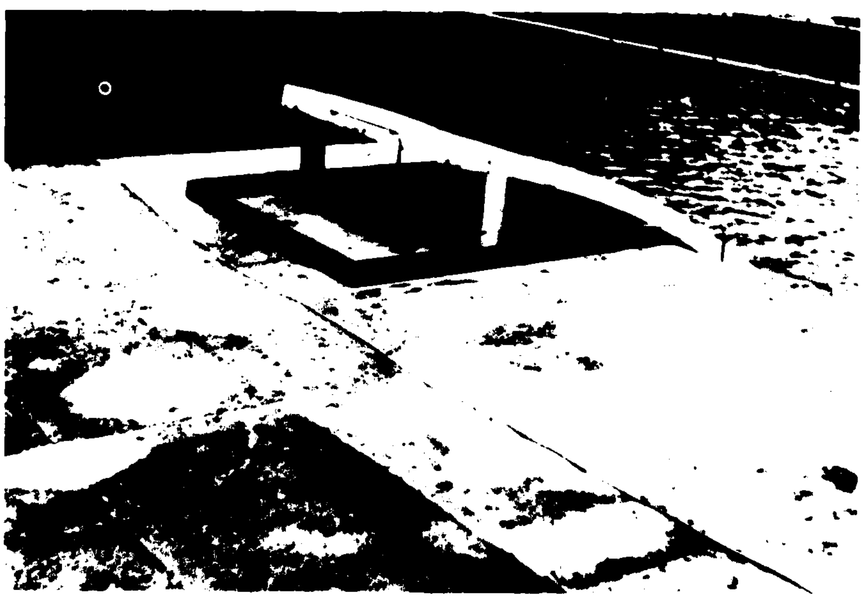
Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY



Boathouse with Boats Suspended in Hoist



Roof of Boathouse and Attached Slide

Boathouse and Surrounding Structures

View of Boathouse from Shore

Boathouse with Slide as Identifying Feature

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Asbestos Roofing*
Background: Water greater than 1.0 metre in depth

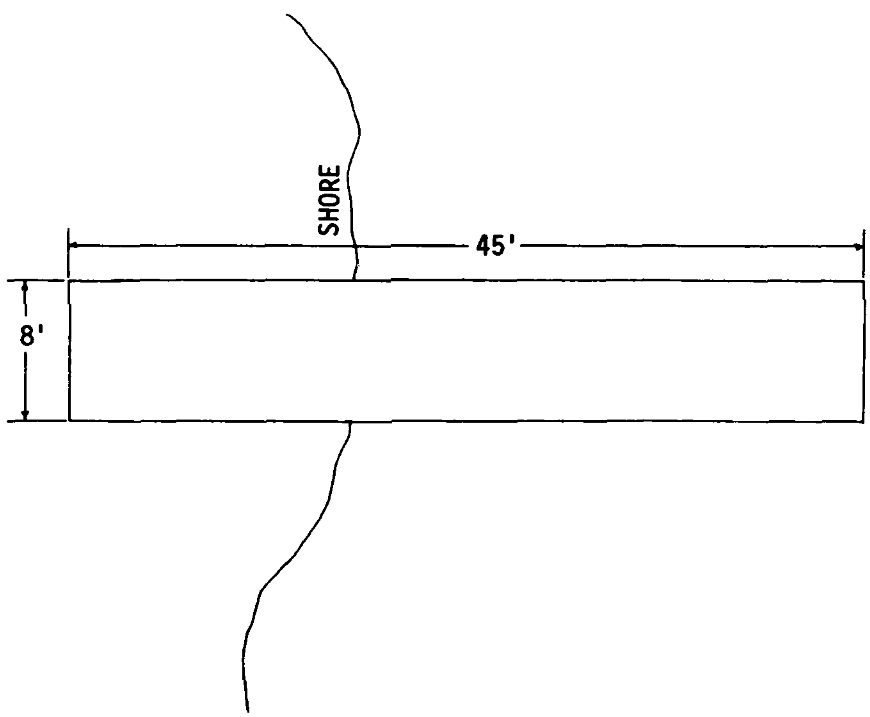
Priority	Film	Filter	Contrast Index
1	2443	12	0.88
2	2443	3	0.85
3	2448	3	0.74
4	2424	87C	0.36

*This feature is not listed in the feature/background matrices (Appendix C); the reflectance signature was obtained from data tapes and the feature's contrast index values were calculated.

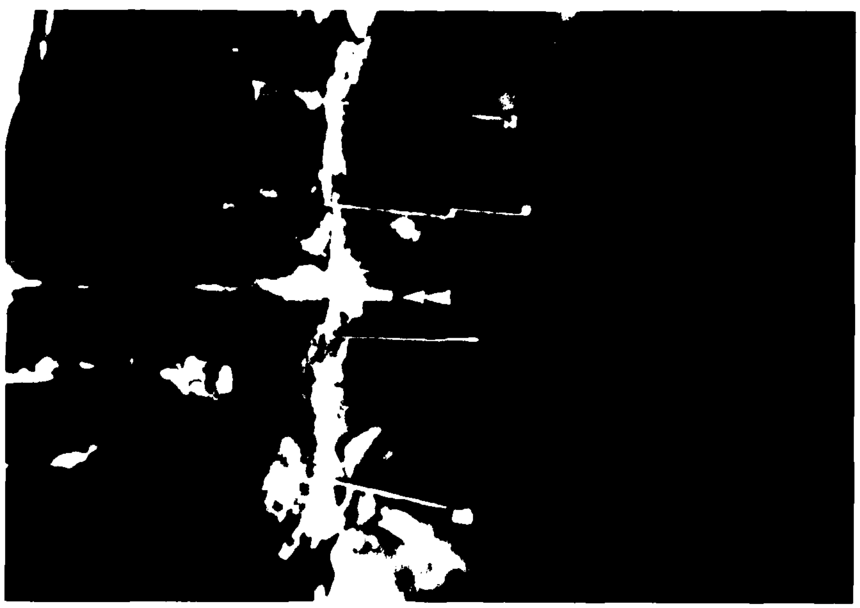
BOAT RAMP

DESCRIPTION: A concrete boat ramp 45 ft long by 8 ft wide

ILLUSTRATION:



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Concrete Boat Ramp Extending into Water

Boat Ramp and Adjacent Structures

OPTIMUM FILM/FILTER COMBINATIONS

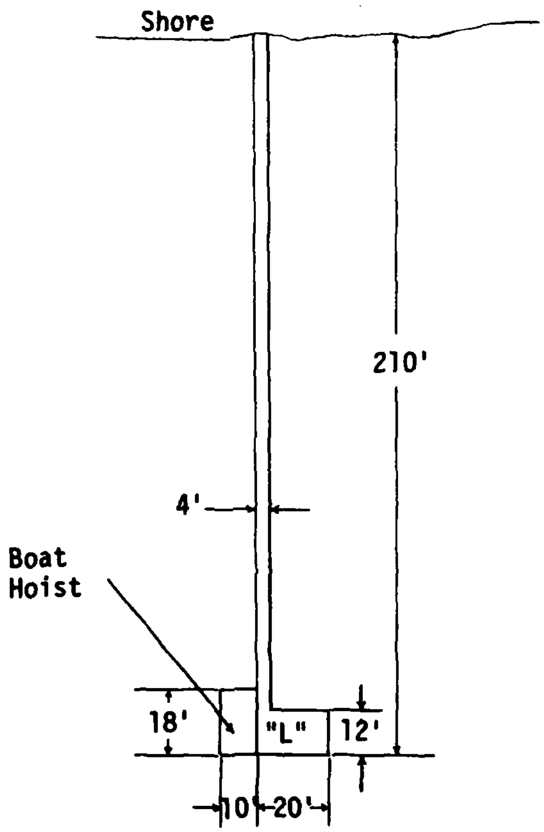
Feature: Concrete Structure
Background: Water less than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2424	87C	0.41
2	2443	3	0.40
3	2424	89B	0.39
4	2443	12	0.38

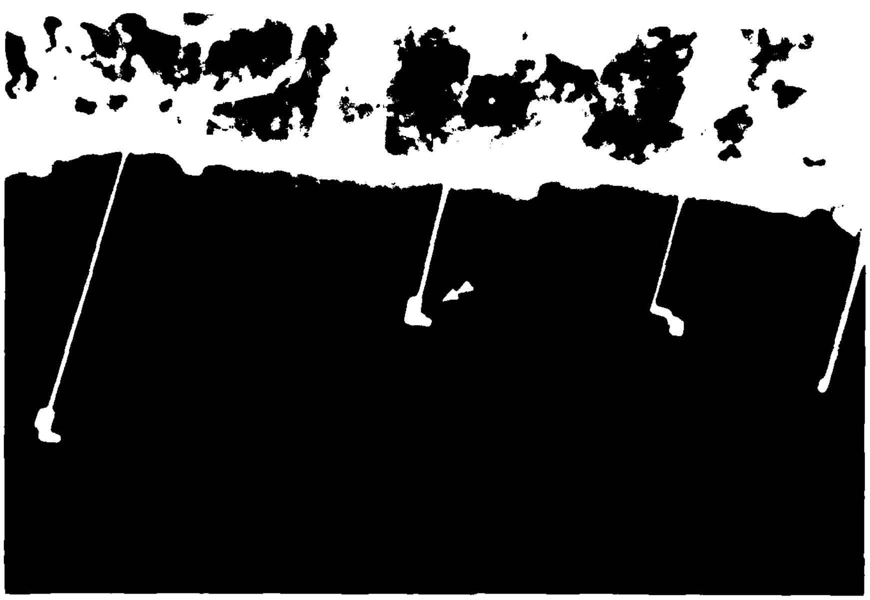
BOAT HOIST

DESCRIPTION: A covered boat hoist 10 by 18 ft adjacent to a pier 4 ft wide with a 12- by 20-ft "L" on the outboard end. Entire length of structure is approximately 210 ft

ILLUSTRATION:

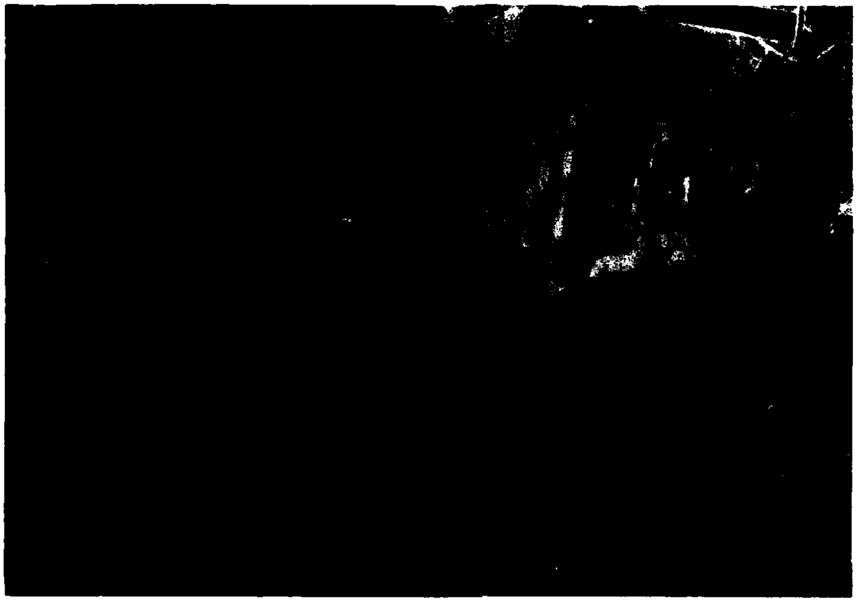


Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

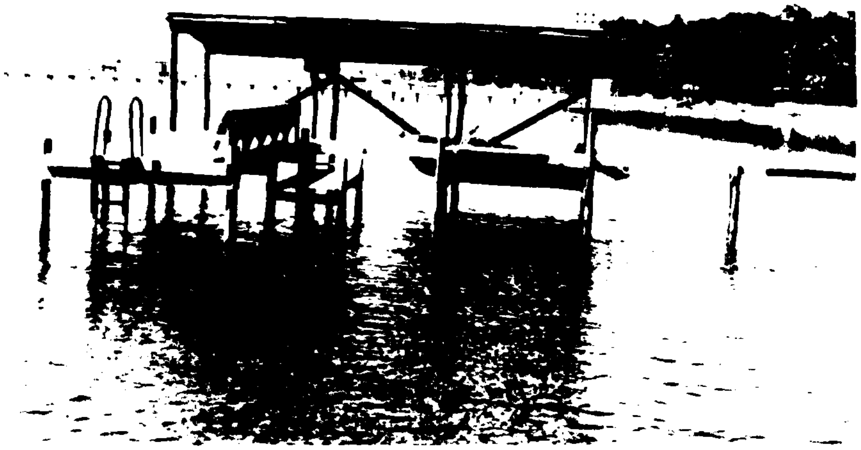
BLACK AND WHITE AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY



Side View of Hoist and Pier

Boat Hoist and Pier as Seen from Adjacent Structure

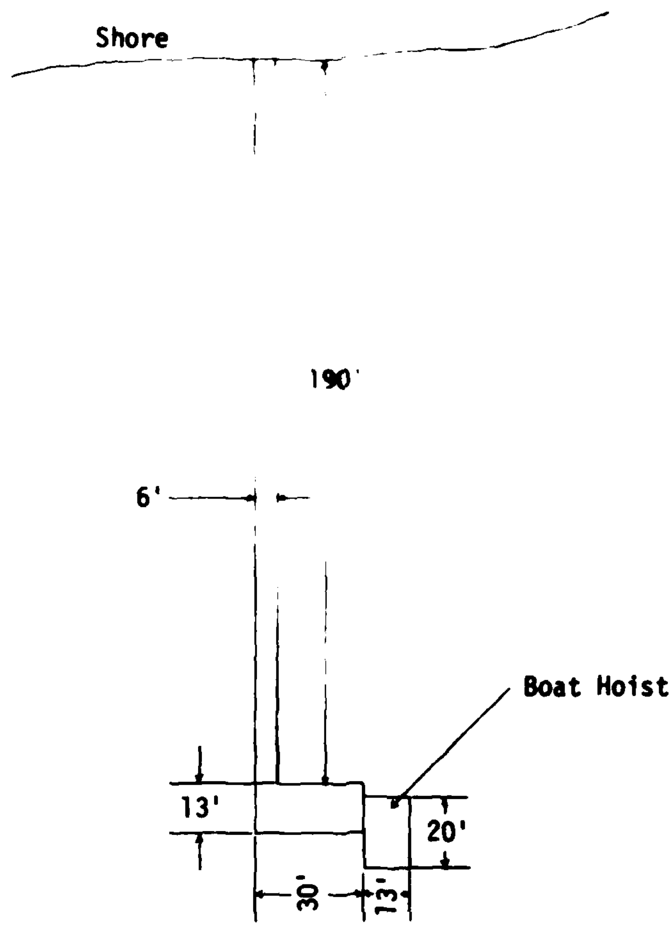
OPTIMUM FILM/FILTER COMBINATIONS

Feature: Metal Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	1.92
2	2443	3	1.80
3	2443	12	1.68
4	2402	47B	0.68

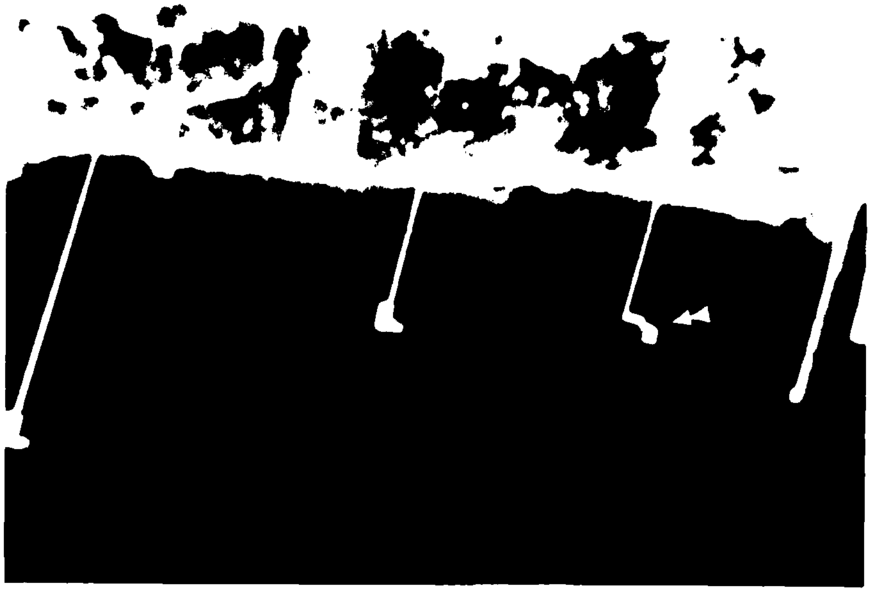
BOAT HOIST

DESCRIPTION: A boat hoist 13 ft wide by 20 ft long built adjacent to a pier 6 ft wide by 190 ft long with a 13- by 30-ft "L" on the outboard end



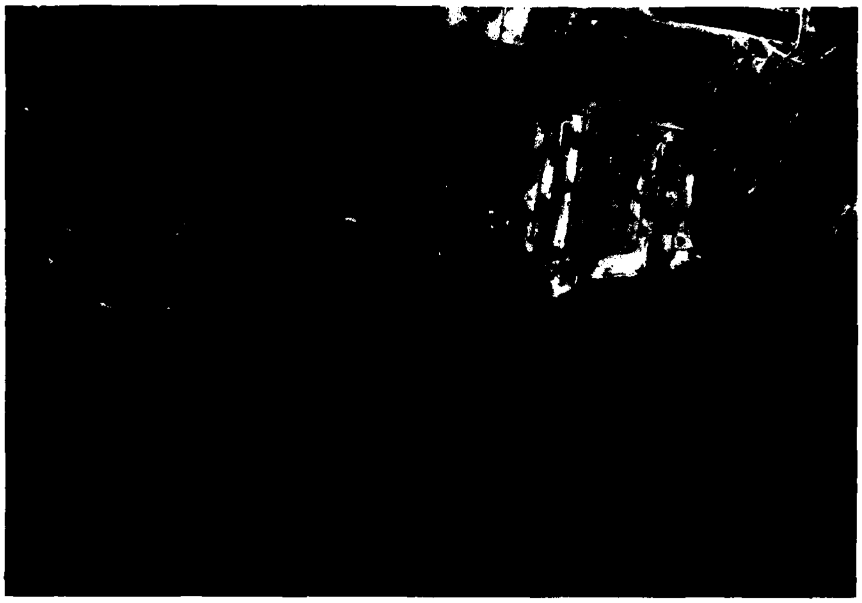
COLOR INFRARED AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRPAHY

Covered Boat Hoist with Adjacent Pier

OPTIMUM FILM/FILTER COMBINATIONS

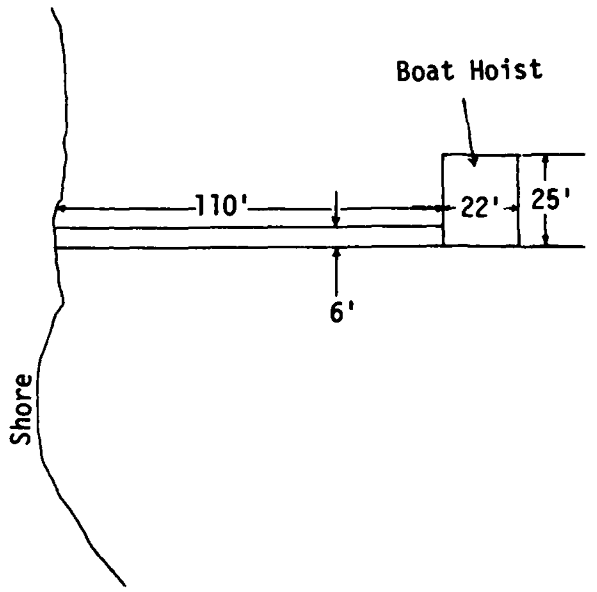
Feature: Wooden Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

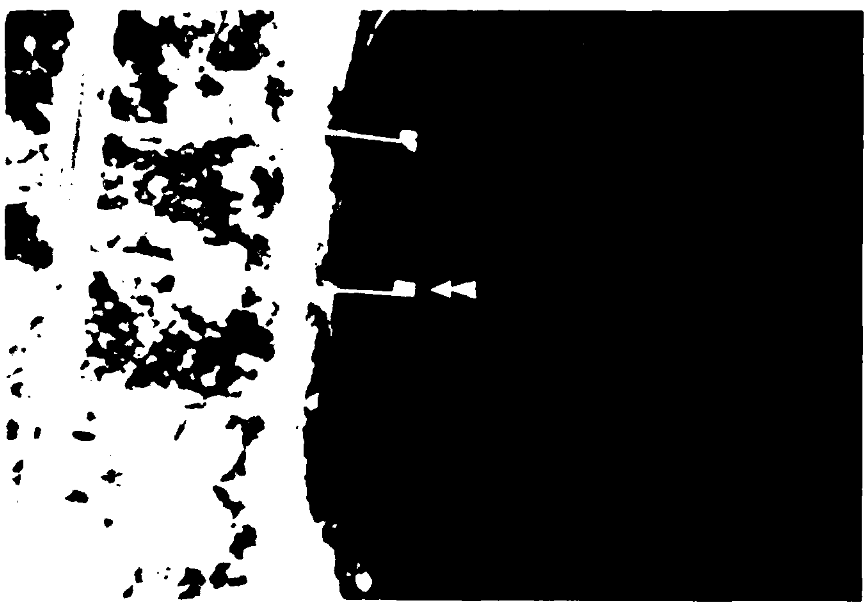
BOAT HOIST

DESCRIPTION: A covered boat hoist 22 ft wide by 25 ft long adjacent to a pier 6 ft wide and 110 ft long

ILLUSTRATION:

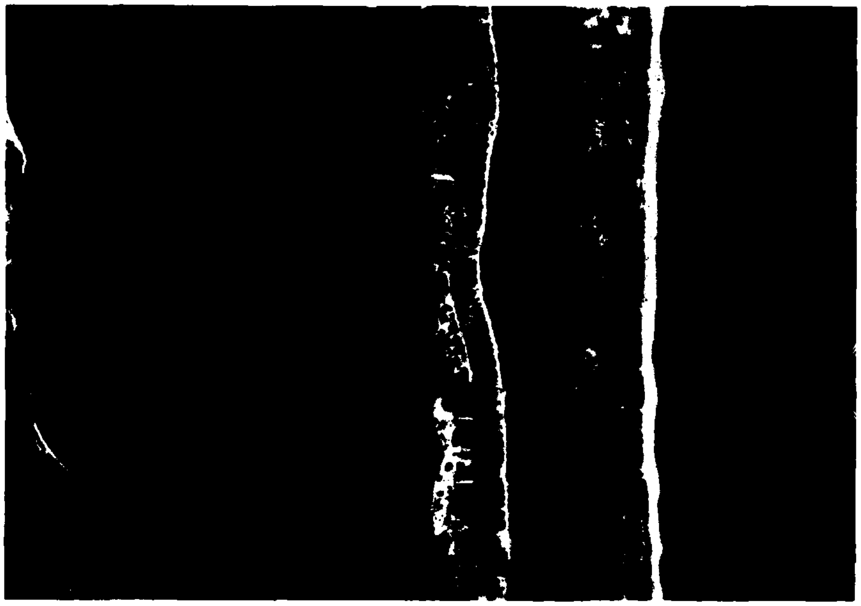


Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

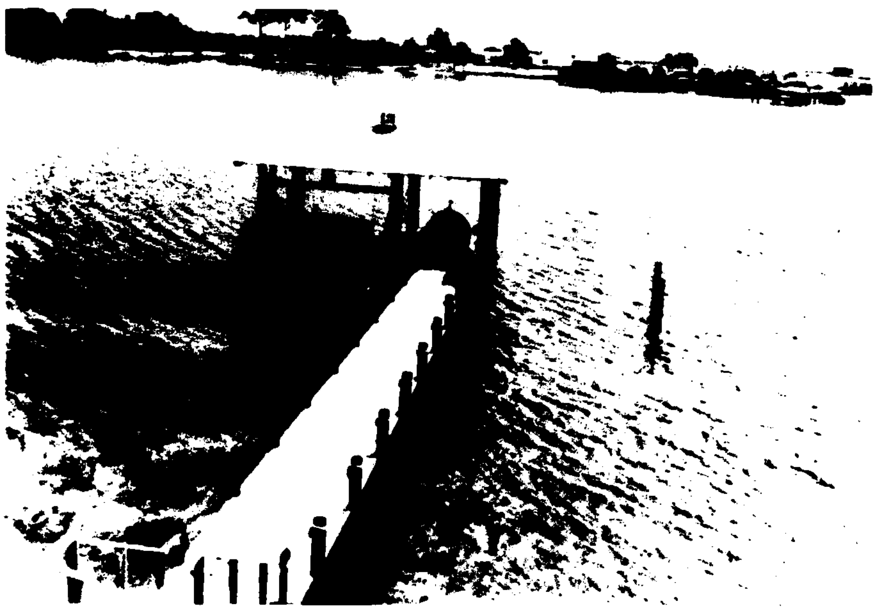
BLACK AND WHITE AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY



Covered Boat Hoist with Pier and Mooring Pilings

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Asbestos Roofing*
Background: Water Greater than 1.0 yd in depth

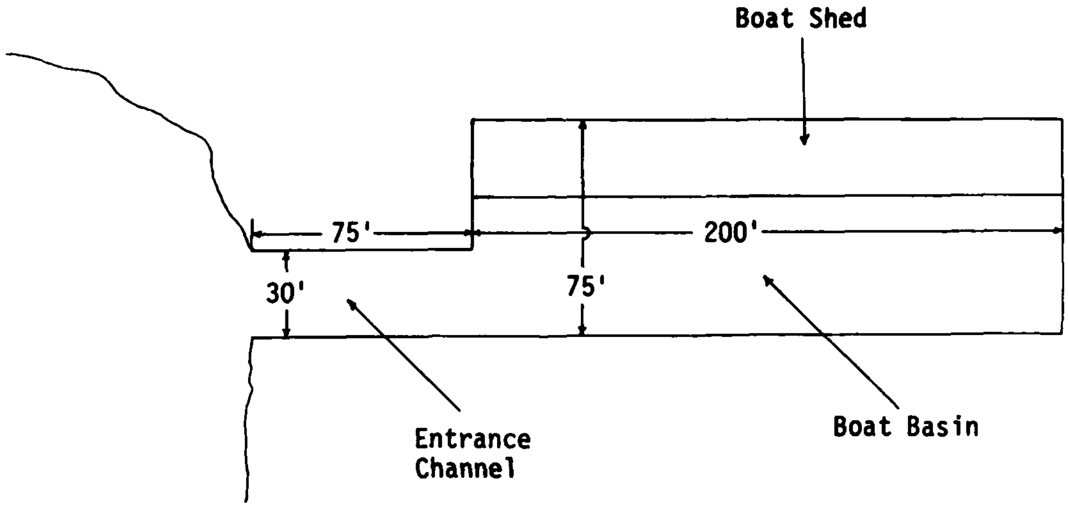
Priority	Film	Filter	Contrast Index
1	2443	12	0.88
2	2443	3	0.85
3	2448	3	0.74
4	2424	87C	0.36

*This feature is not listed in the feature/background matrices (Appendix C); the reflectance signature was obtained from data tapes and the feature's contrast index values were calculated.

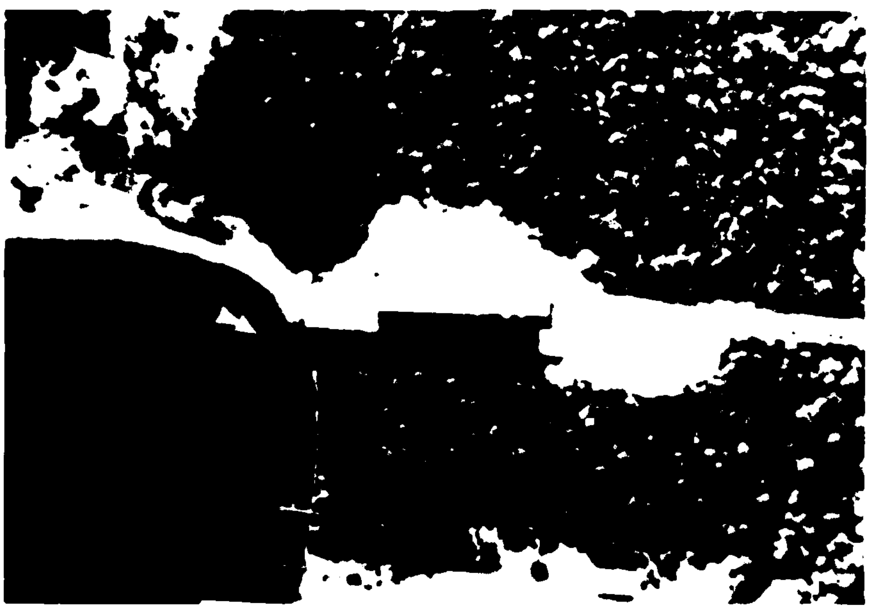
BOAT BASIN

DESCRIPTION: An upland boat basin constructed by dragline dredging an area 75 by 200 ft with an entrance channel 75 by 30 ft to a depth of 6 ft below mean low water. Approximately 4444 cu yd sand removed and placed on upland site

ILLUSTRATION:



Feature Area at a Scale of 1:24,000



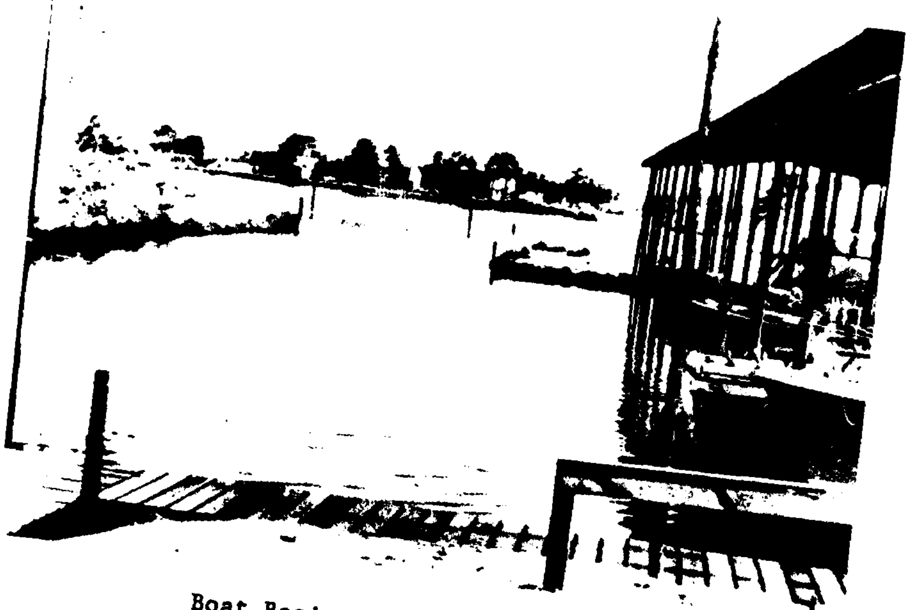
Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY



Boat Basin and Entrance Channel

Marina Adjacent to Basin

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Water greater than 1.0 yd in depth
Background: Beach Sand

Priority	Film	Filter	Contrast Index
1	2443	3	3.53
2	2448	3	3.52
3	2443	12	3.48
4	2424	87C	1.10

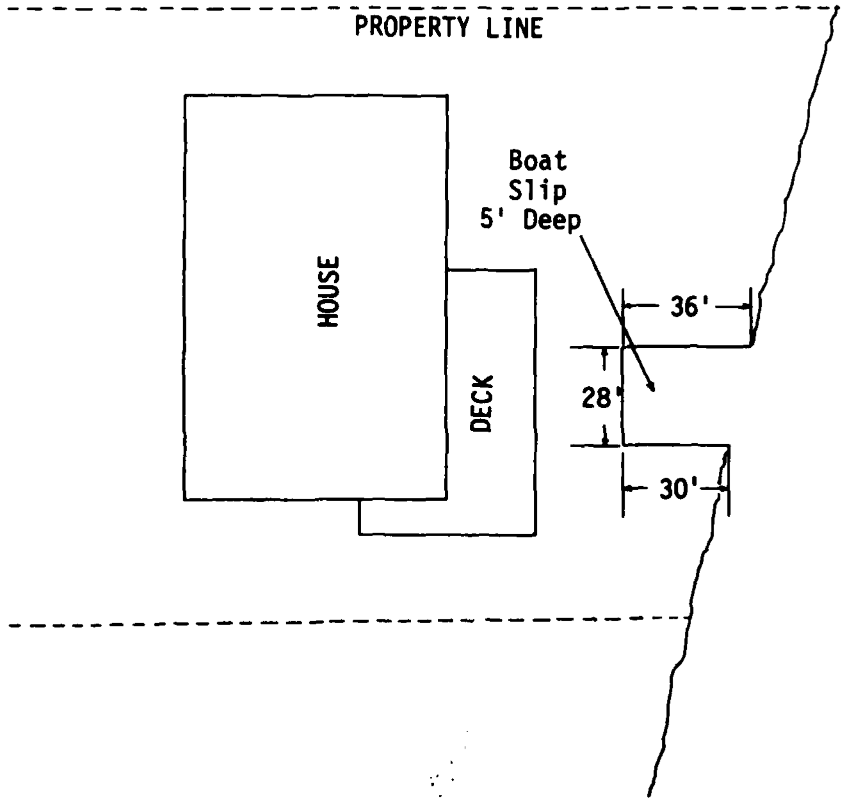
Feature: Water greater than 1.0 yd in depth
Background: Grass

Priority	Film	Filter	Contrast Index
1	2443	12	0.74
2	2443	3	0.65
3	2424	87C	0.63
4	2424	89B	0.60

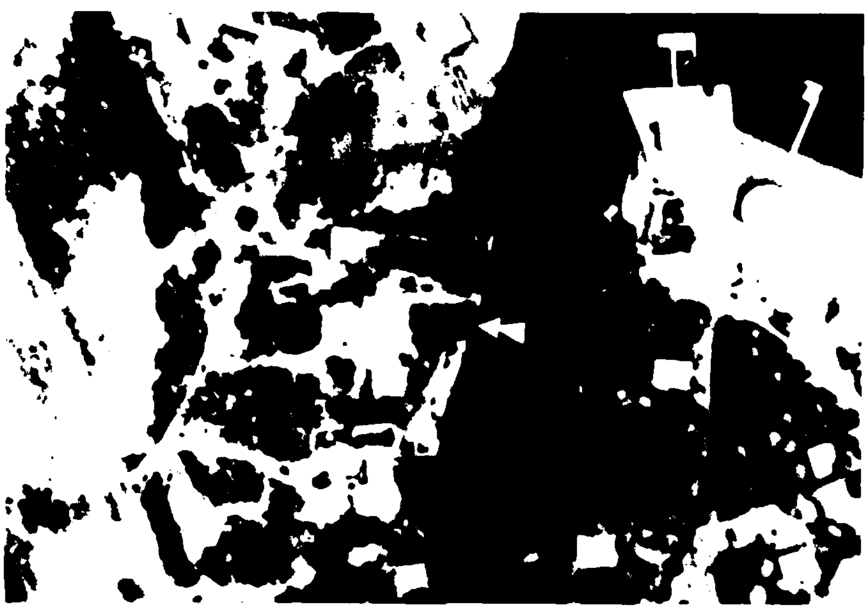
BOAT SLIP

DESCRIPTION: A boat slip 28 by 30 by 36 ft with a depth of 5 ft below mean low tide. Approximately 200 cu yd of material removed by dragline placed on upland property of adjacent property owners

ILLUSTRATION:



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Interior of Slip

Mouth of Slip

OPTIMUM FILM/FILTER COMBINATIONS

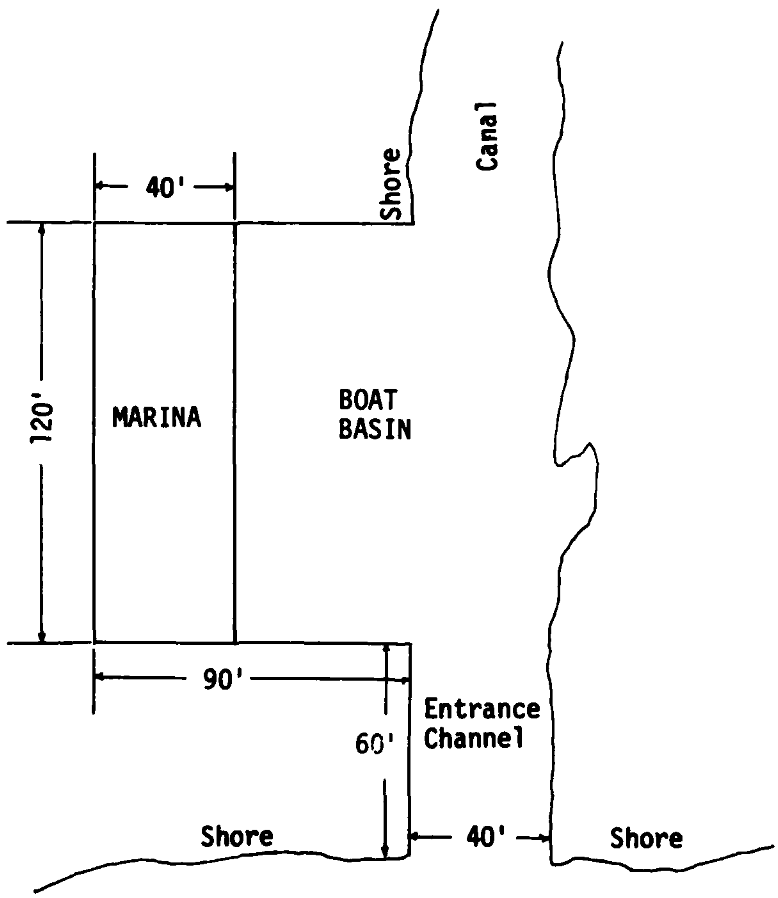
Feature: Marsh
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2424	87C	0.29
2	2424	89B	0.28
3	2443	12	0.23
4	2443	3	0.19

MARINA

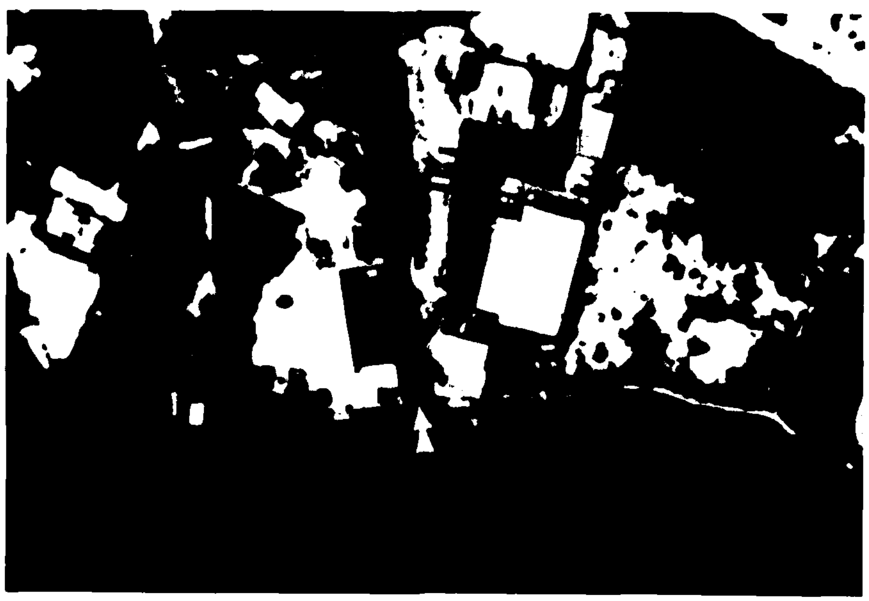
DESCRIPTION: A marina consisting of one docking facility 40 ft wide by 120 ft long located in a boat basin 90 ft wide by 120 ft long. Adjacent to the basin is a canal and an entrance channel 40 ft wide by 60 ft long

ILLUSTRATION:

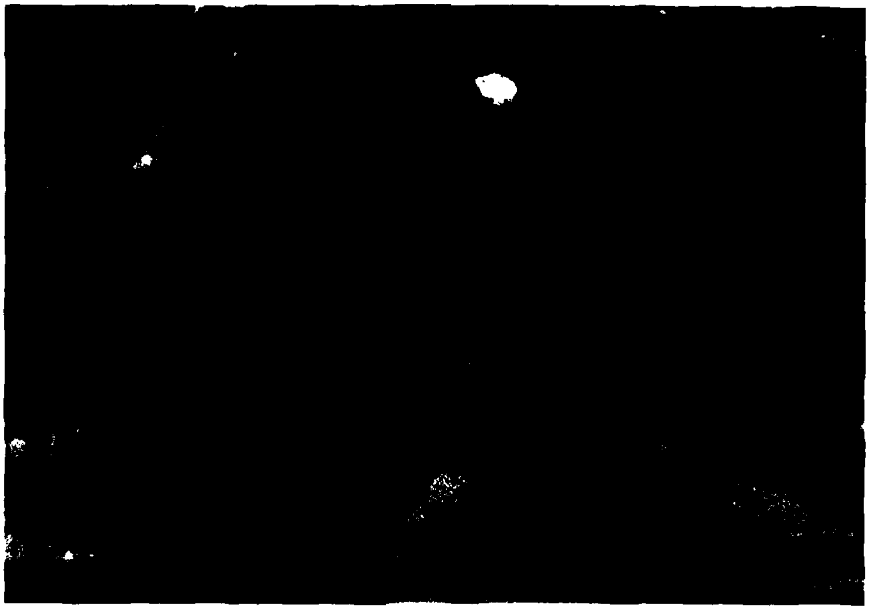


COLOR INFRARED AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000



Enlargement of Feature Area



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Marina Facility with Covered Boat Stalls

Docked Boats in Metal-Topped Structure

Canal Located Behind Marina

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Metal Structure
Background: Beach Sand

Priority	Film	Filter	Contrast Index
1	2443	12	1.80
2	2443	3	1.72
3	2448	3	1.60
4	2424	87C	0.62

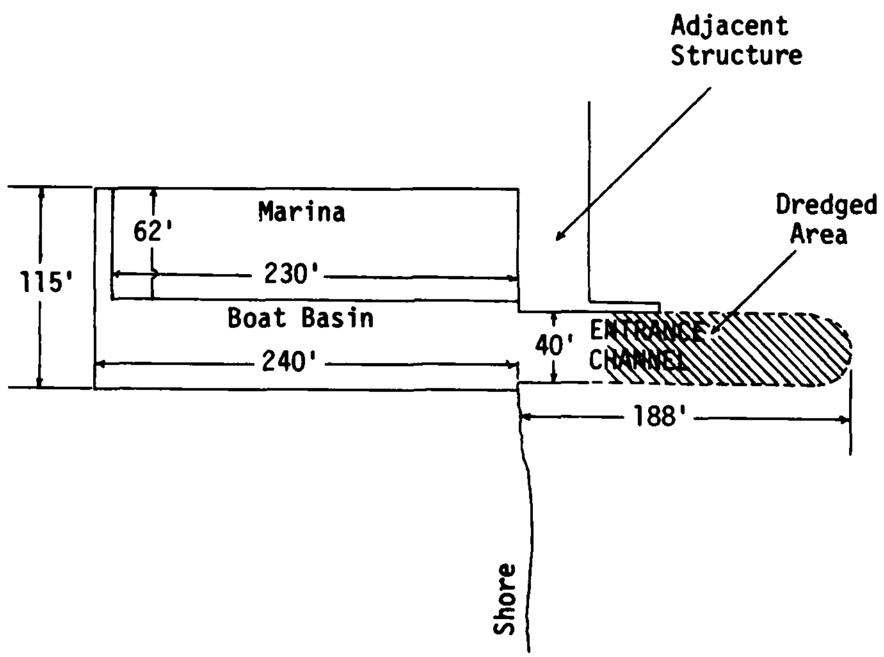
Feature: Metal Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	1.92
2	2443	3	1.80
3	2443	12	1.68
4	2402	47B	0.68

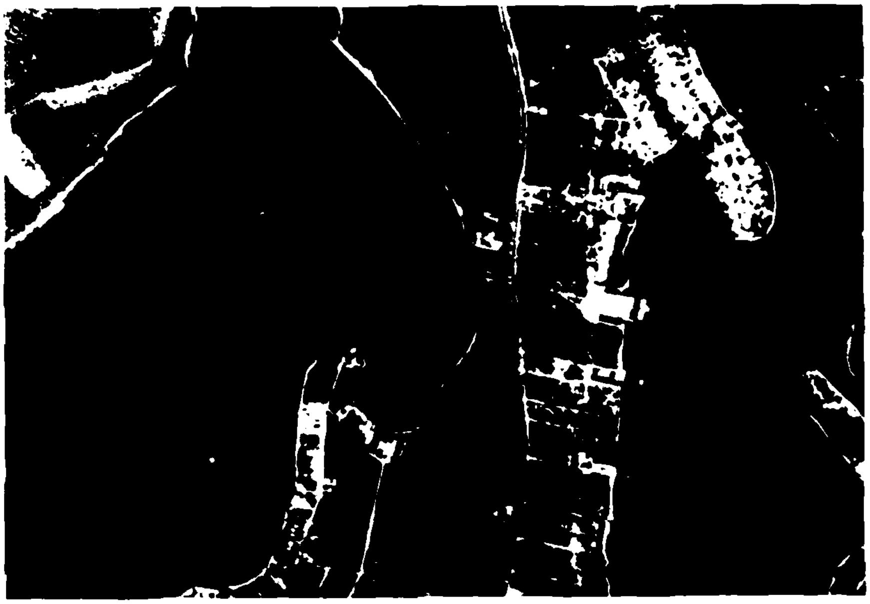
MARINA

DESCRIPTION: A marina with a metal-covered docking facility 62 by 230 ft located in a 240- by 115-ft boat basin with a 188- by 40-ft entrance channel

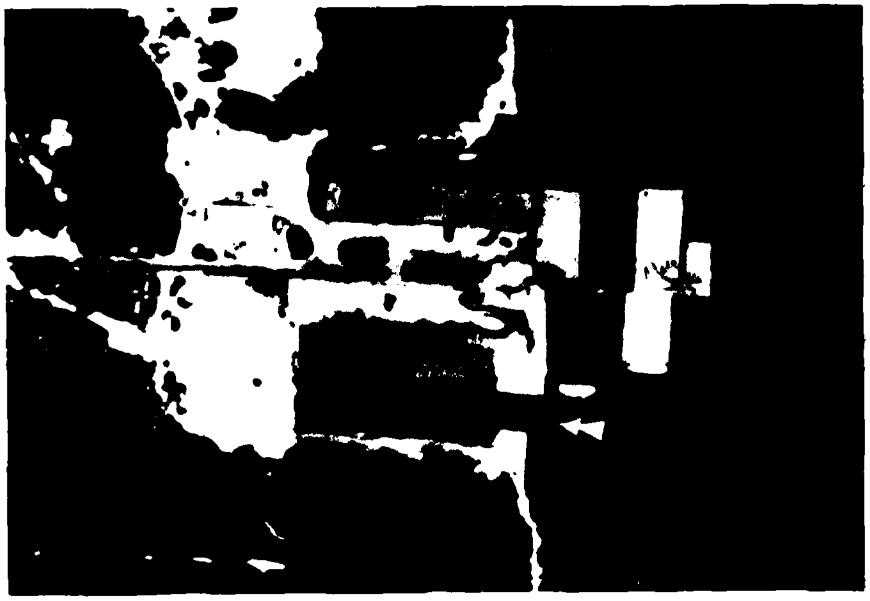
ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Interior of Marina Basin

Structures Adjoining Marina Basin

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Metal Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	1.92
2	2443	3	1.80
3	2443	12	1.68
4	2402	47B	0.68

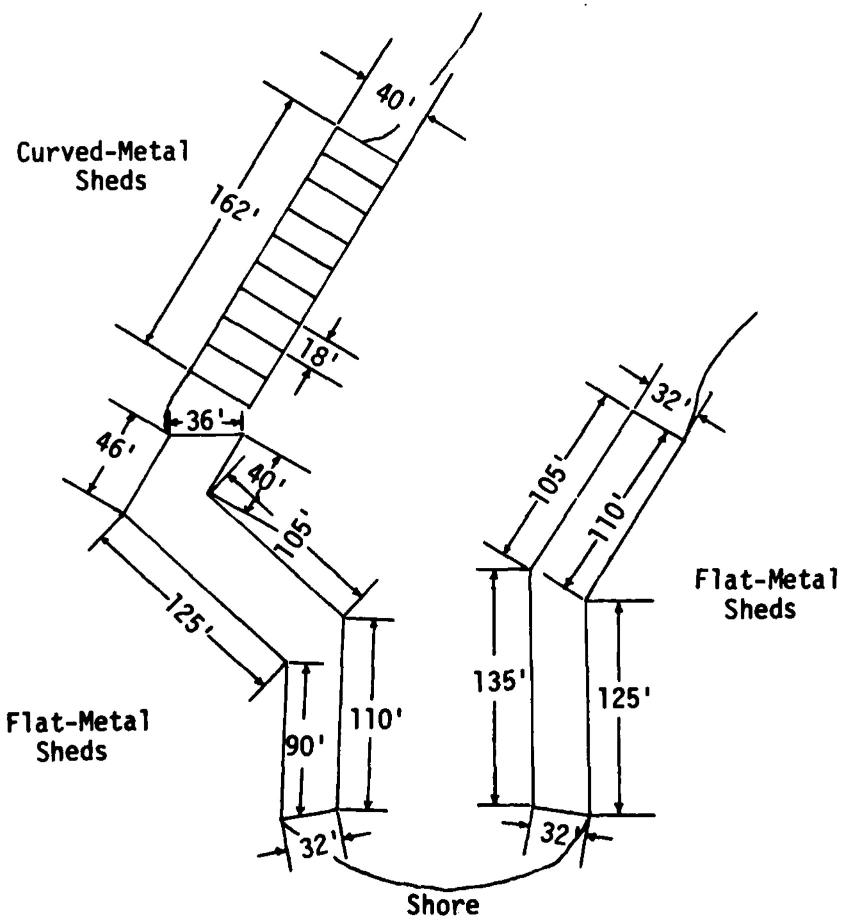
Feature: Metal Structure
Background: Beach sand

Priority	Film	Filter	Contrast Index
1	2443	12	1.80
2	2443	3	1.72
3	2448	3	1.60
4	2424	87C	0.62

MARINA

DESCRIPTION: A marina with three docking facilities: two irregularly shaped with flat-metal tops and the third 40 by 162 ft with 9 curved-metal-topped stalls each 18 ft in width

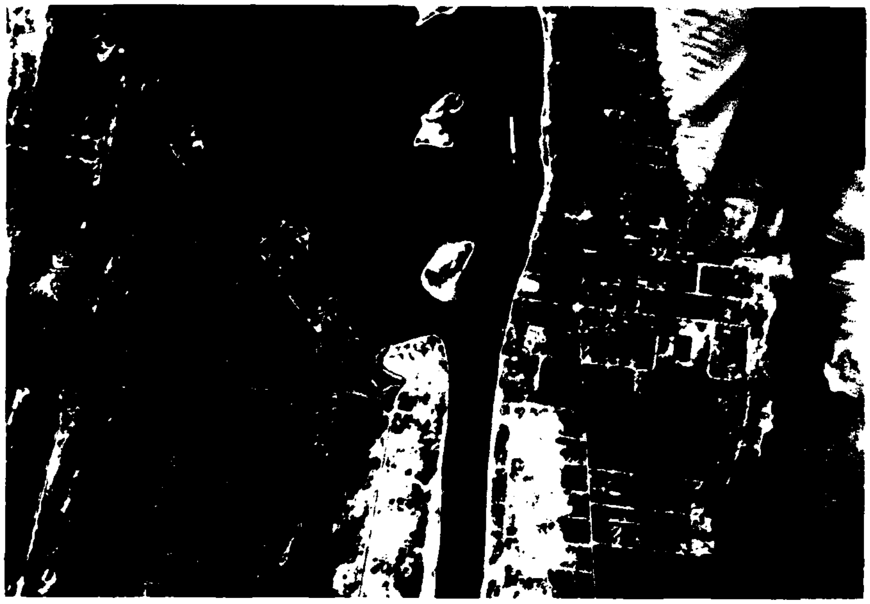
ILLUSTRATION:



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

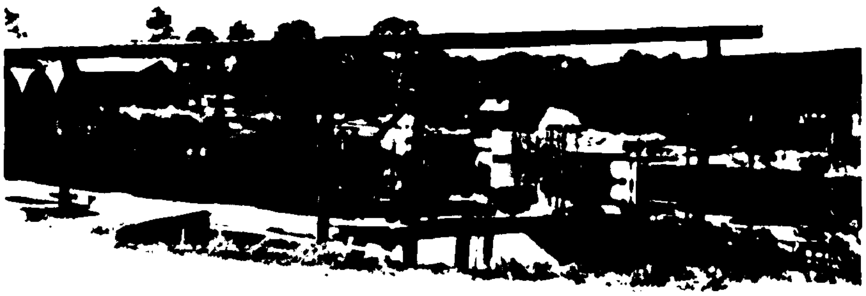
BLACK AND WHITE AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000

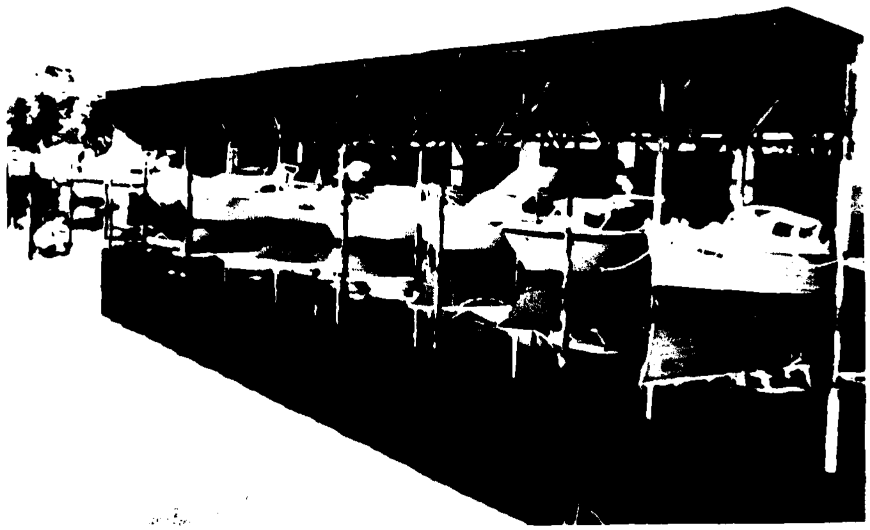
Enlargement of Feature Area

GROUND PHOTOGRAPHY



Comprehensive View of Marina Facilities

Boat Sheds with Curved-Metal Roofs



Docking Structure with Flat-Metal Roof

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Metal Structure
Background: Beach Sand

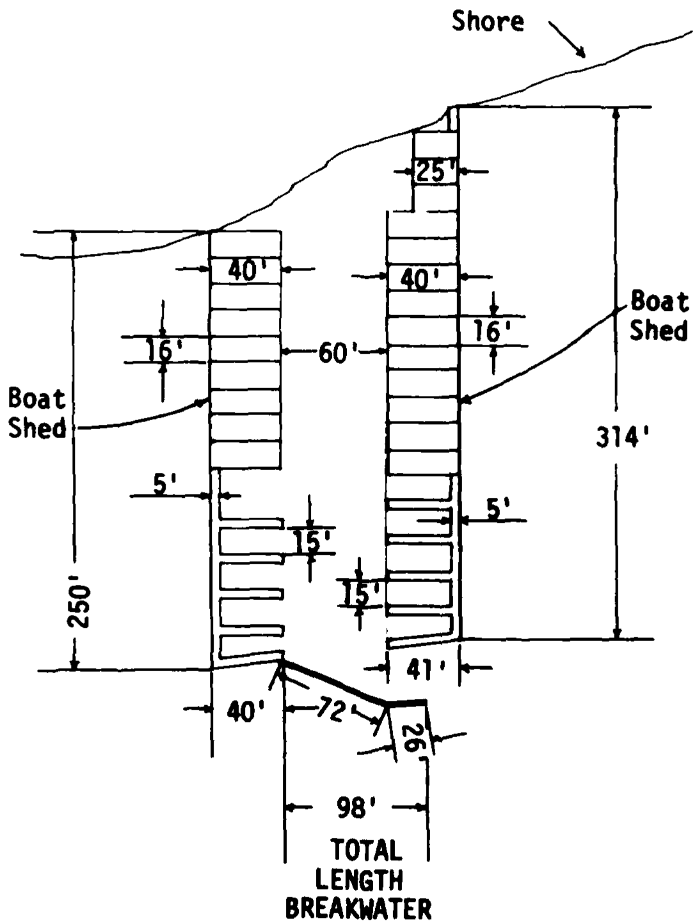
Priority	Film	Filter	Contrast Index
1	2443	12	1.80
2	2443	3	1.72
3	2448	3	1.60
4	2424	87C	0.62

Feature: Metal Structure
Background: Water greater than 1.0 yd in depth

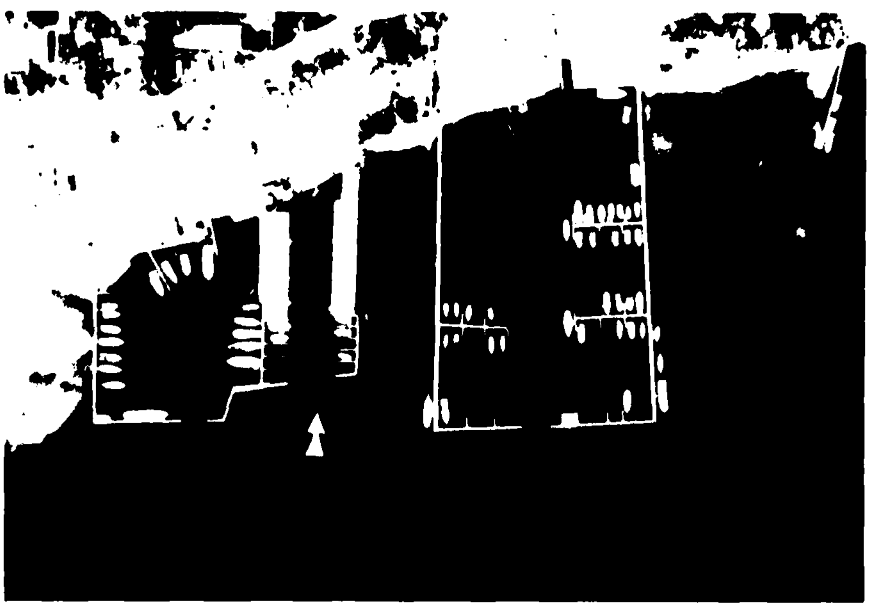
Priority	Film	Filter	Contrast Index
1	2448	3	1.92
2	2443	3	1.80
3	2443	12	1.68
4	2402	47B	0.68

MARINA

DESCRIPTION: A marina comprised of two docking facilities: one consisting of a wooden pier 314 ft long and 5 ft wide adjacent to which are 13 metal-topped boat sheds and 5 uncovered boat slips and the other composed of a wooden pier 250 ft long and 5 ft wide with 9 metal-topped boat sheds and 5 uncovered boat slips. Boats entering the marina pass a 98-ft breakwater

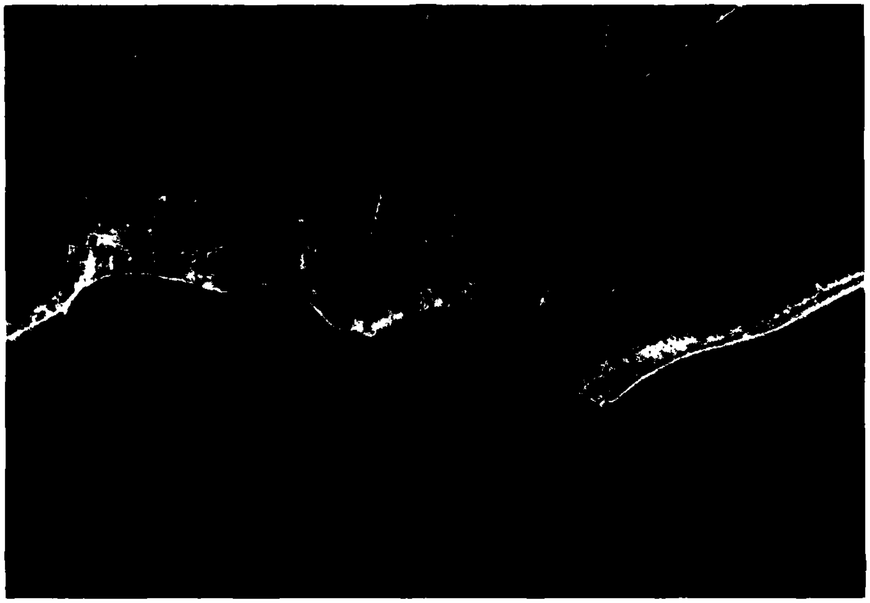


Feature Area at a Scale of 1:24,000

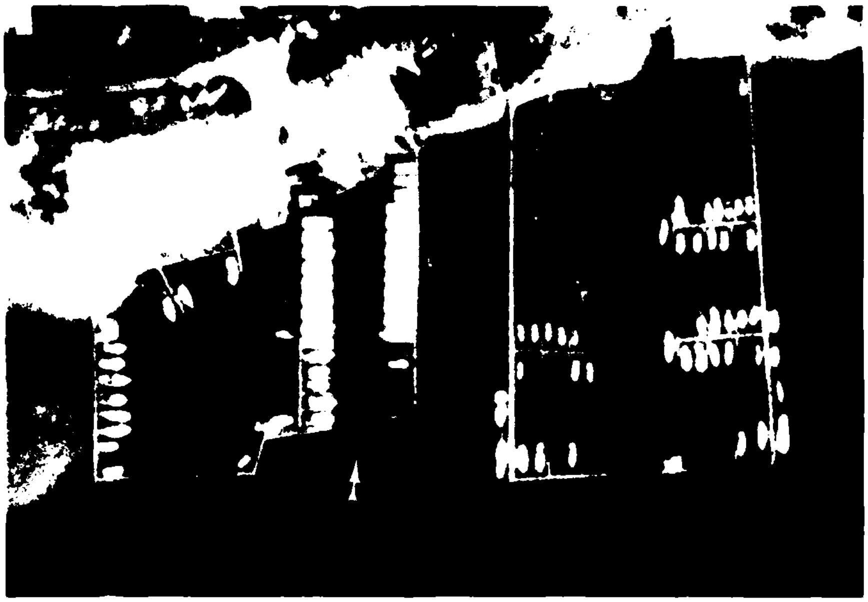


Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

GROUND PHOTOGRAPHY

Marina Facilities as Seen from Shore

Boat Sheds of Different Heights

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Metal Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	1.92
2	2443	3	1.80
3	2443	12	1.68
4	2402	47B	0.68

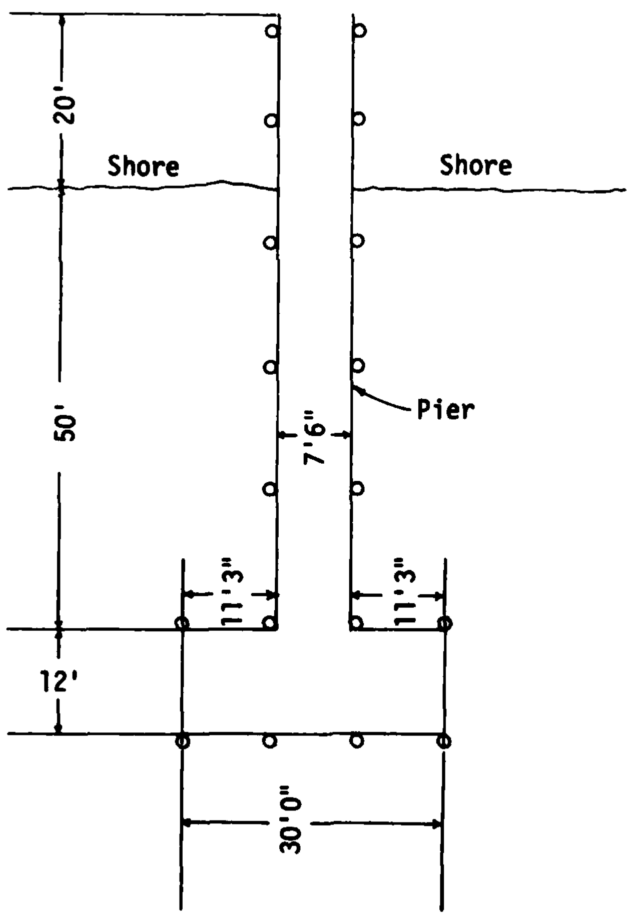
Feature: Wooden Structure
Background: Water greater than 1.0 yd in depth

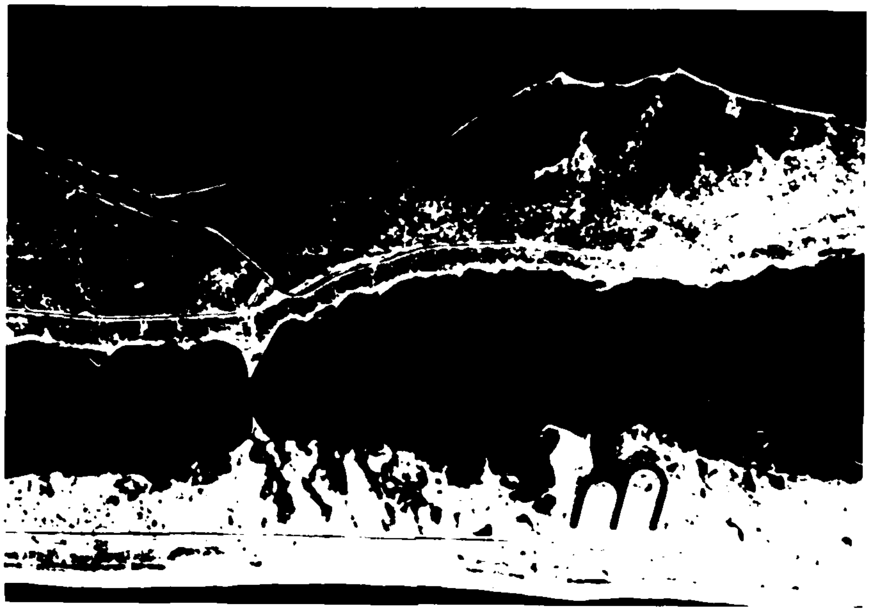
Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

T-SHAPED PIER

DESCRIPTION: A private wooden pier 7 ft 6 in. wide with a 30- by 12-ft "T" on the outboard end. The entire length of the structure is 82 ft

ILLUSTRATION:





Feature Area at a Scale of 1:24,000

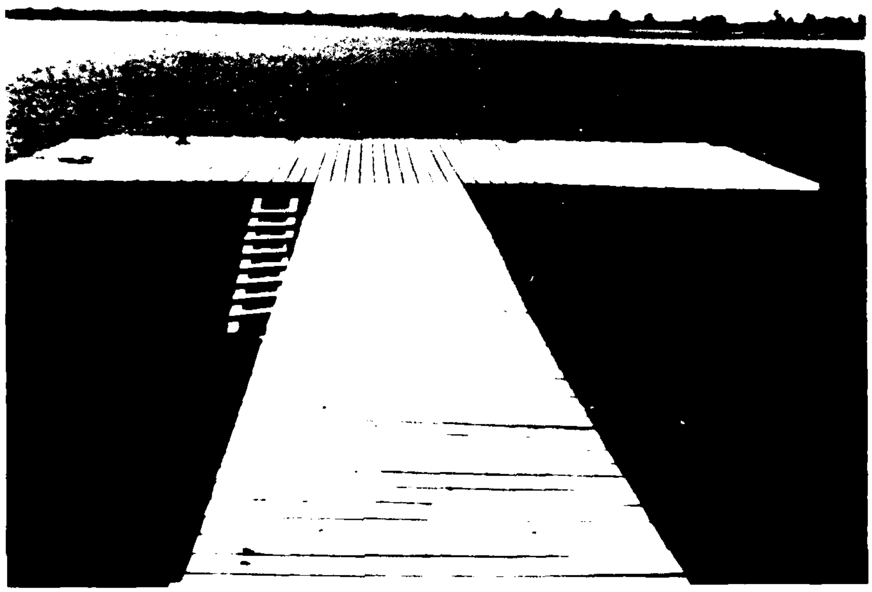
Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

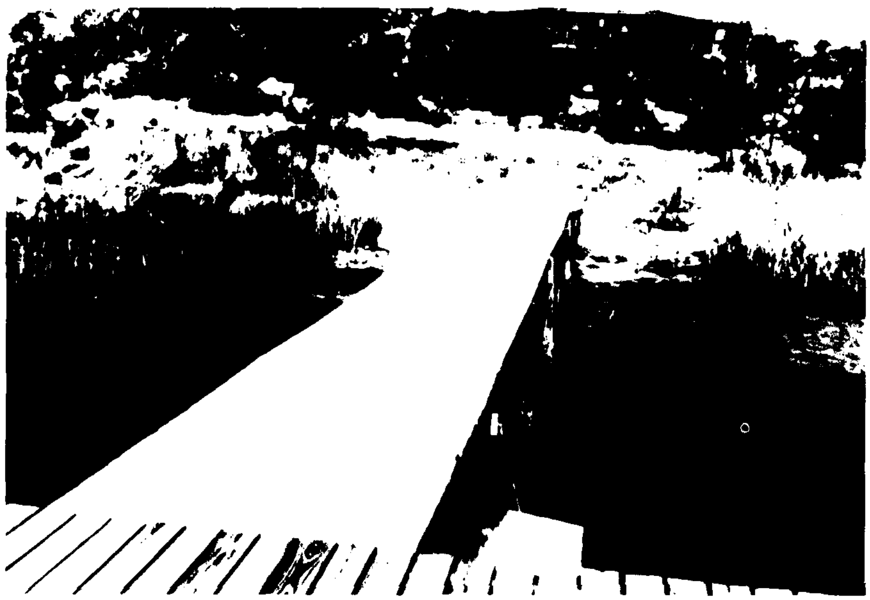
Enlargement of Feature Area

GROUND PHOTOGRAPHY



Outboard End of Pier

View of Pier from Shore



Shoreward End of Pier

OPTIMUM FILM/FILTER COMBINATIONS

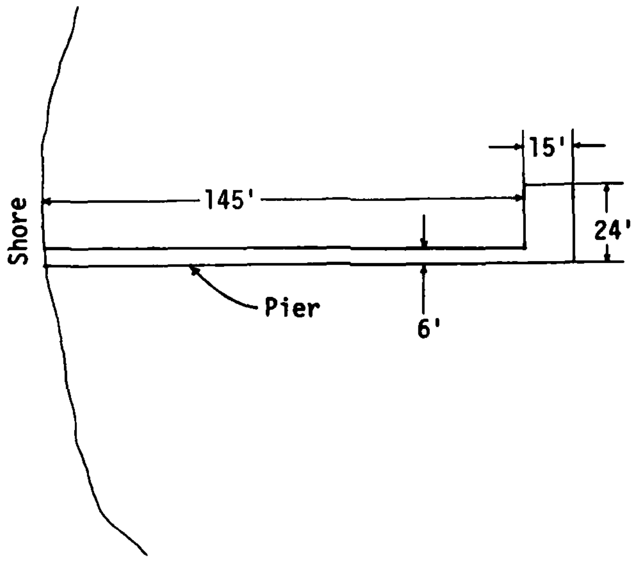
Feature: Wooden Structure
Background: Water less than 1.0 yd but greater than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	0.54
2	2443	3	0.48
3	2443	12	0.44
4	2402	47B	0.21

L-SHAPED PIER

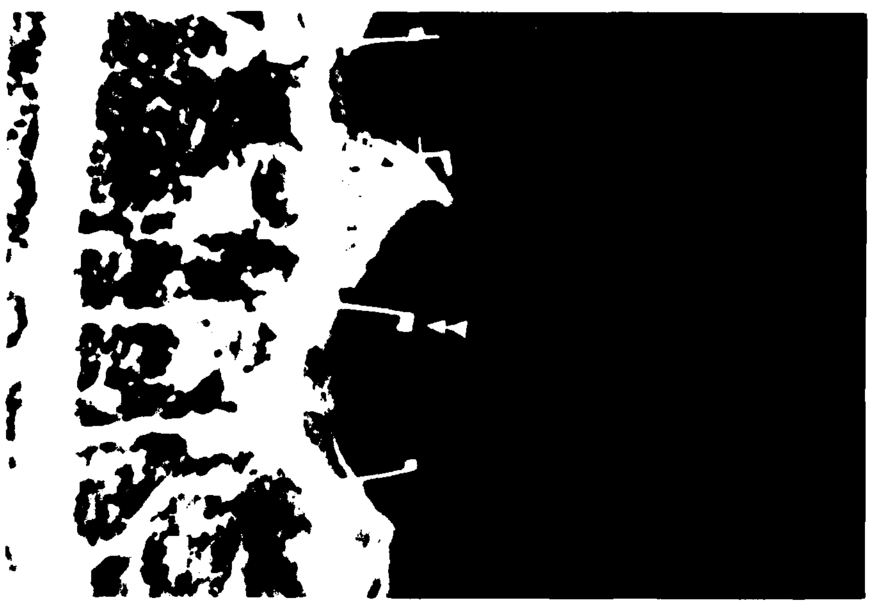
DESCRIPTION: A wooden pier 6 ft wide by 145 ft long with a 15-ft-wide by 24-ft-long "L" on the outboard end

ILLUSTRATION:



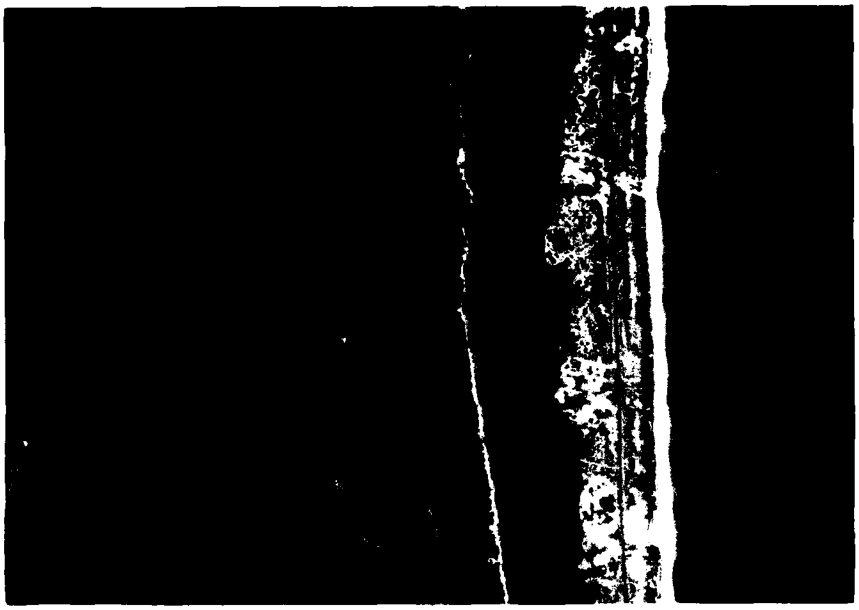
COLOR INFRARED AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

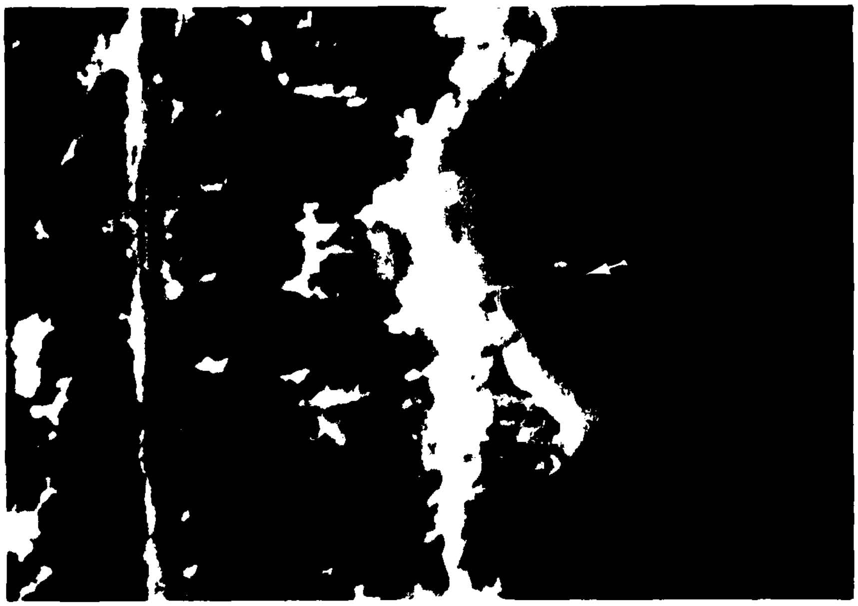


Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

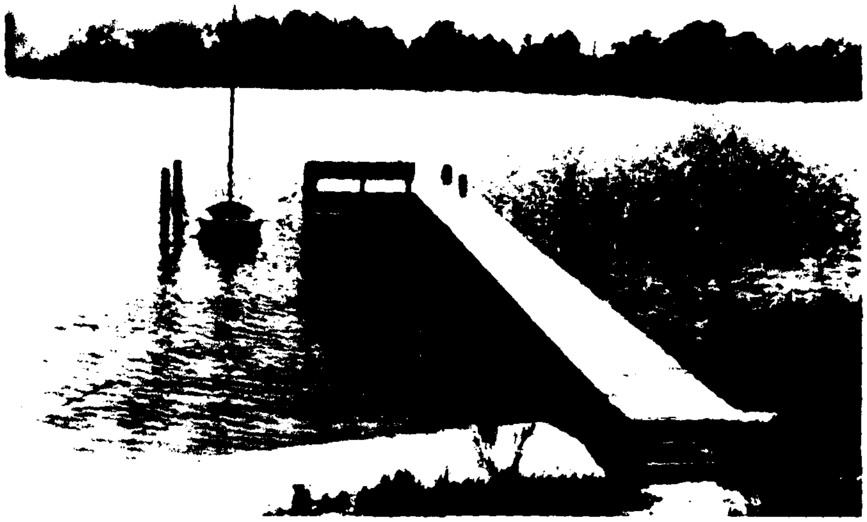


Feature Area at a Scale of 1:24,000

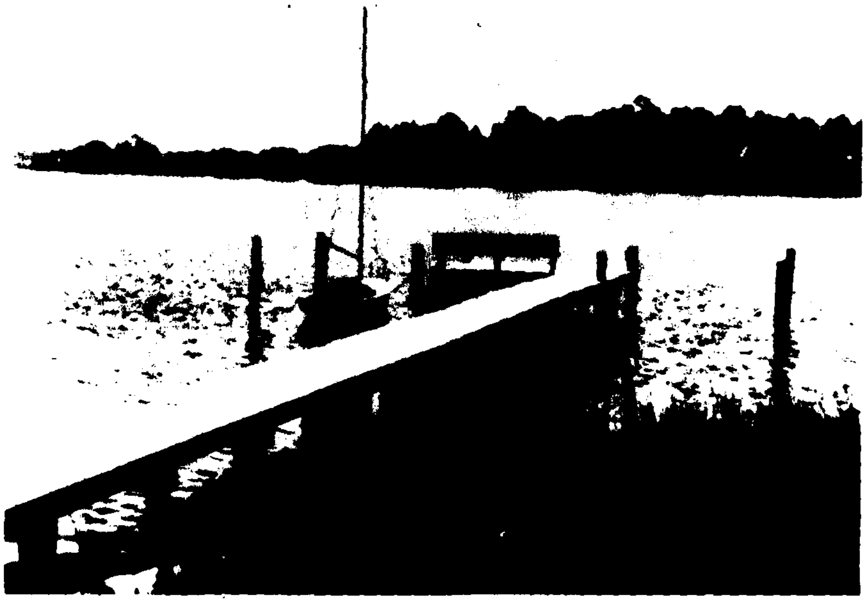


Enlargement of Feature Area

GROUND PHOTOGRAPHY



L-Shaped Pier with Mooring Pilings



Shoreward End of Pier with Black Rush in Foreground

Side View of Pier with Beach Sand in Foreground

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Wooden Structure
Background: Water less than 1.0 yd but greater than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	0.54
2	2443	3	0.48
3	2443	12	0.44
4	2402	47B	0.21

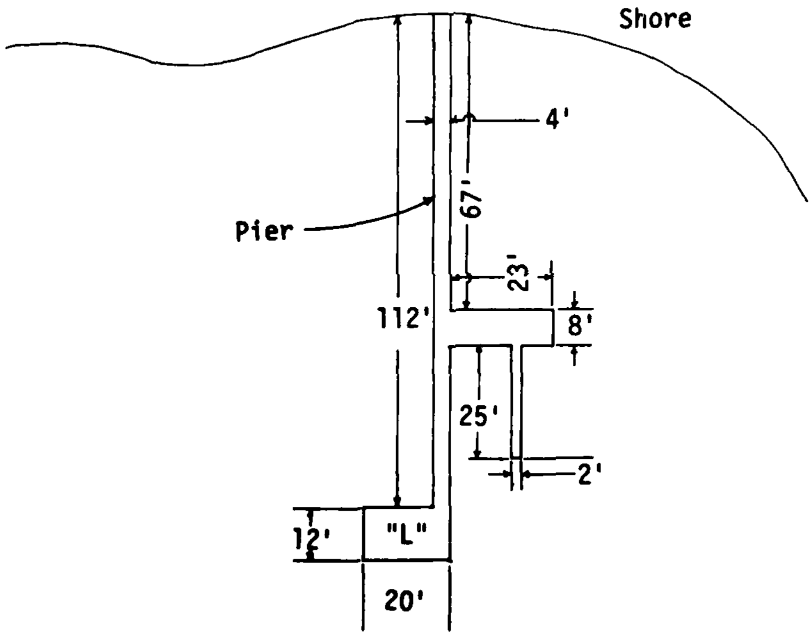
Feature: Wooden Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

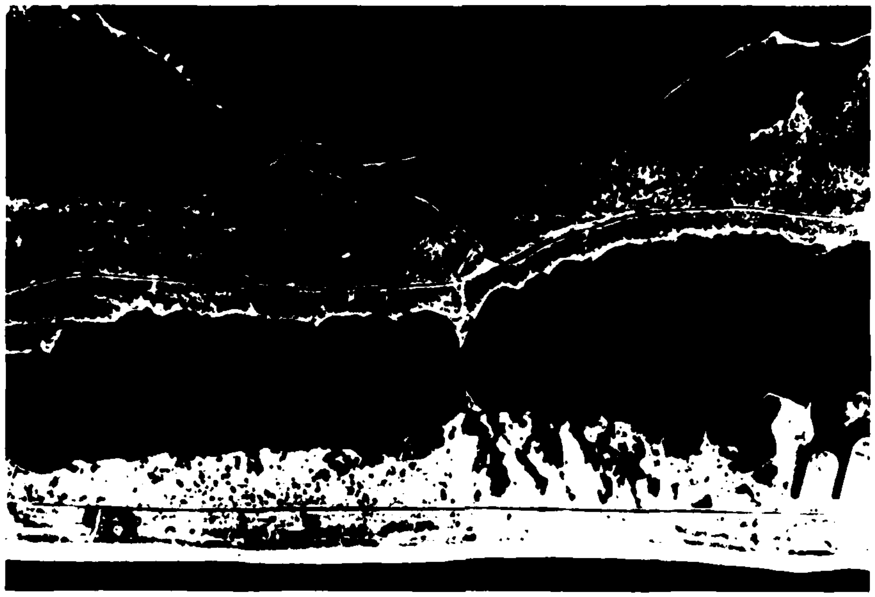
WOODEN PIER

DESCRIPTION: A wooden pier 4 by 112 ft with a 12- by 20-ft "L" on the outboard end and a 8- by 23-ft "L" 67 ft from shore, with a 2- by 25-ft pier extension

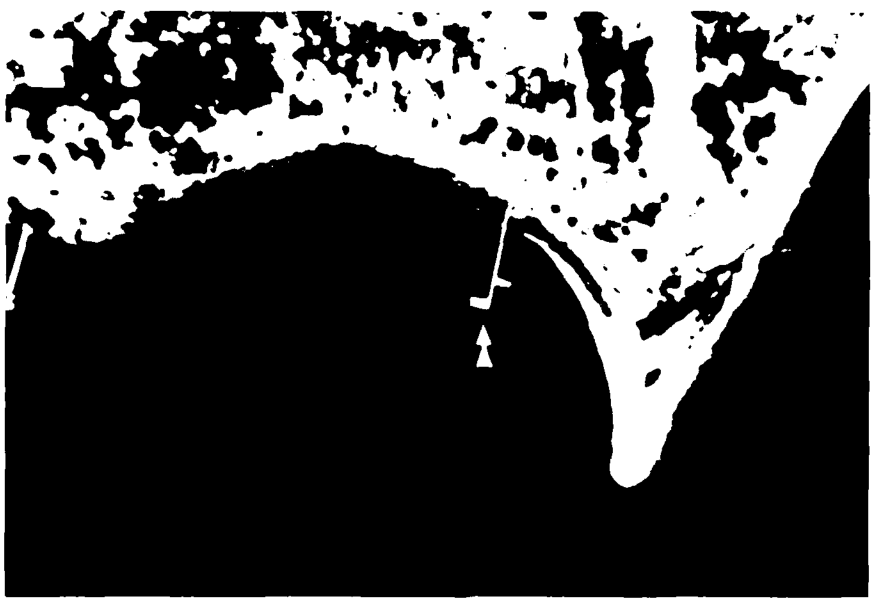
ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Wooden Pier with Black Rush in Foreground

Pier and Adjacent Mooring Pilings

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Wooden Structure
Background: Water less than 1.0 yd but greater than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	0.54
2	2443	3	0.48
3	2443	12	0.44
4	2402	47B	0.21

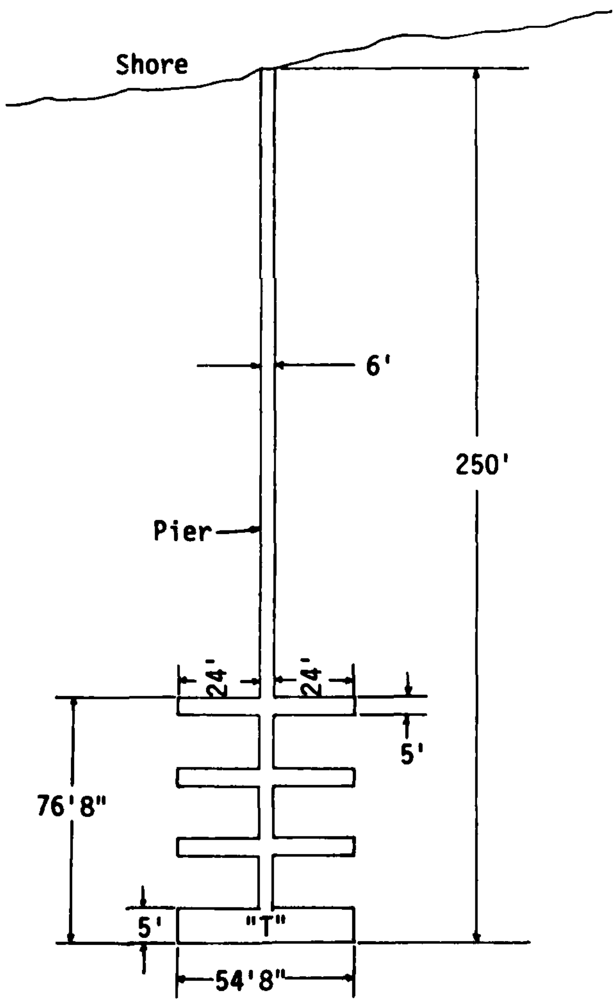
Feature: Wooden Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

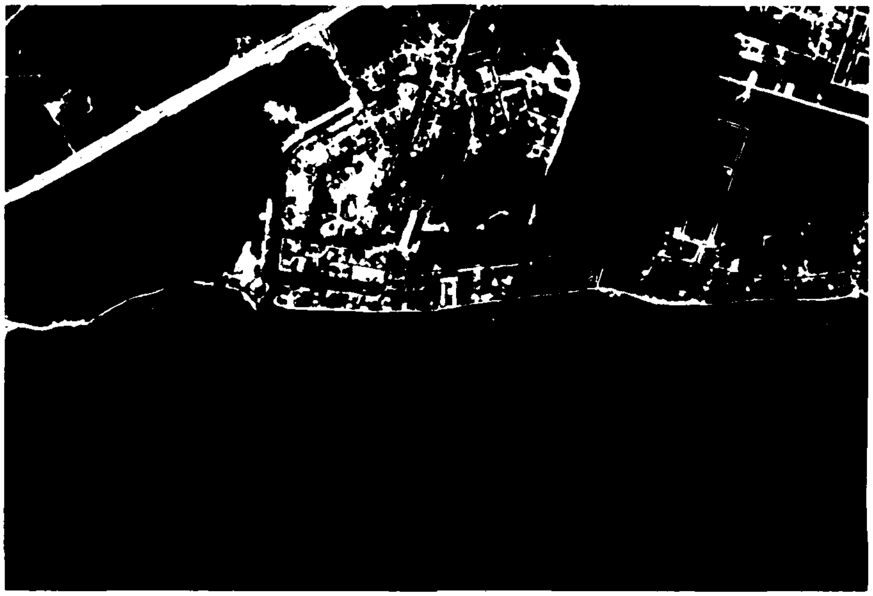
PIER WITH EXTENSIONS

DESCRIPTION: A 6-ft-wide pier with six opposite extensions 24 ft in length and a "T" 54 ft 8 in. by 10 ft on the outboard end. Extensions commence approximately 76 ft 8 in. from the outboard end and the entire structure extends 250 ft beyond the mean high water line

ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY



Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

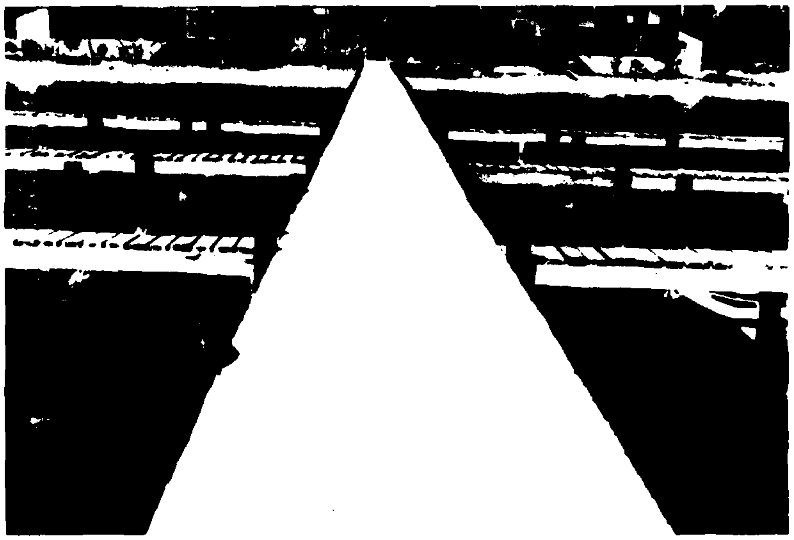
BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

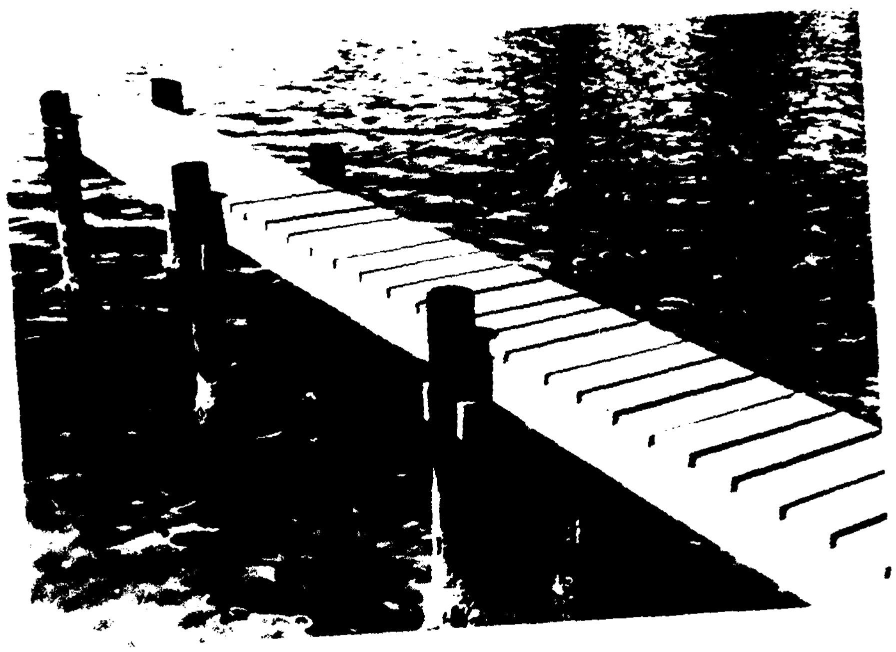
Enlargement of Feature Area

GROUND PHOTOGRAPHY

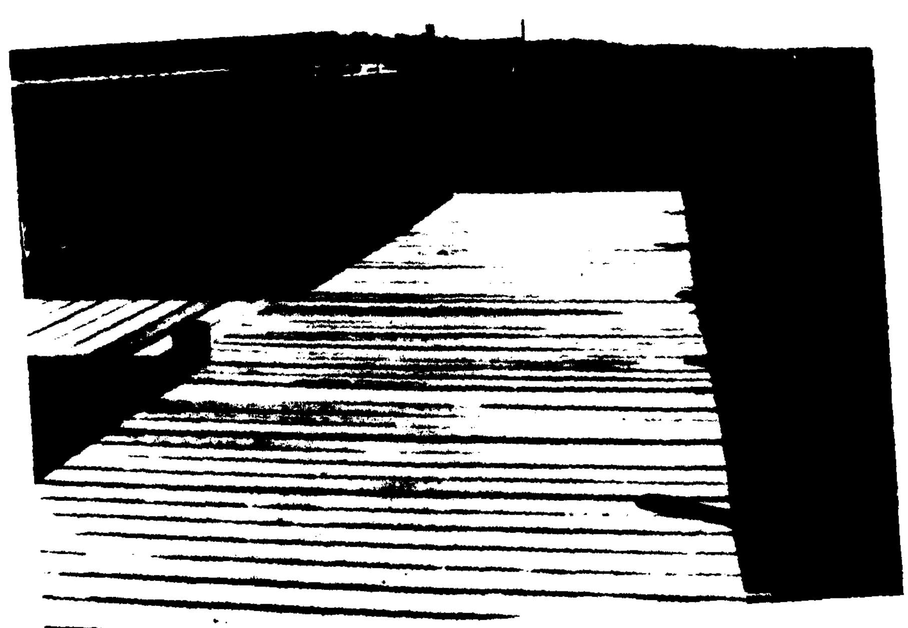
Outboard End of Pier



View Facing Shore of Pier and Extensions



Close-Up of Pier Extension



"T" on Outboard End of Pier

OPTIMUM FILM/FILTER COMBINATIONS

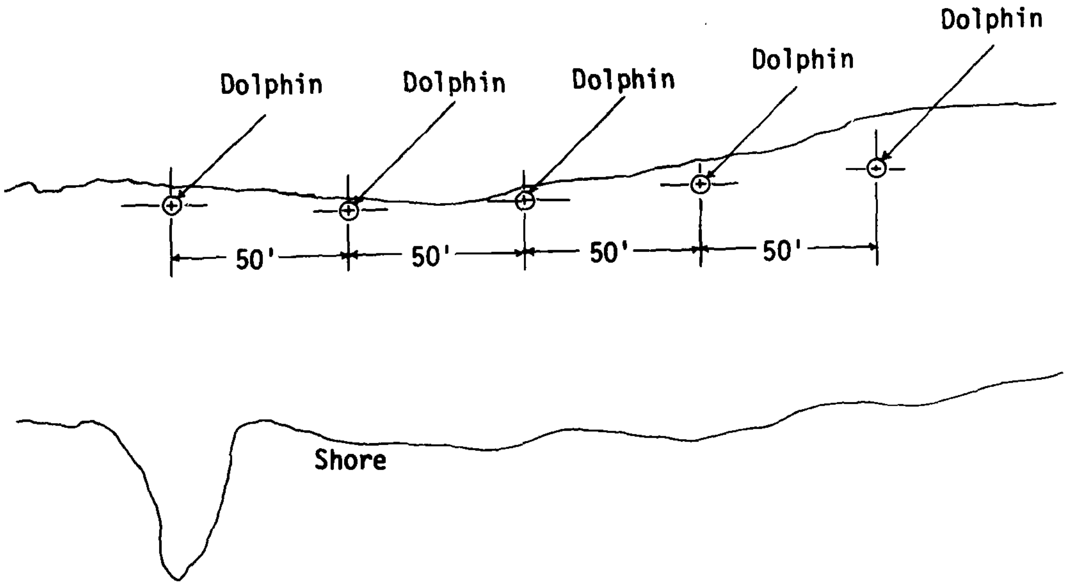
Feature: Wooden Structure
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

DOLPHINS

DESCRIPTION: Five dolphins spaced approximately 50 ft apart, each constructed by binding together 5 or 6 creosoted timber pilings with steel cable

ILLUSTRATION:

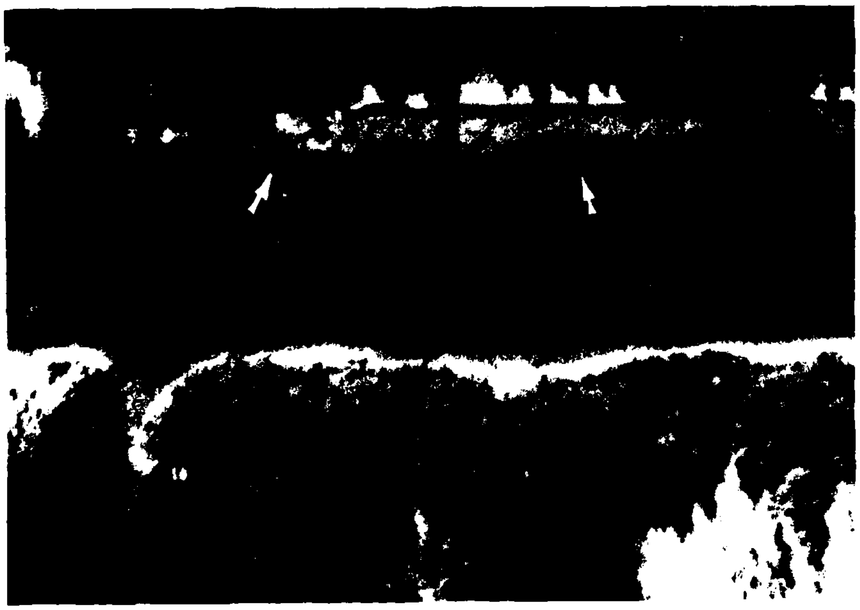


Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

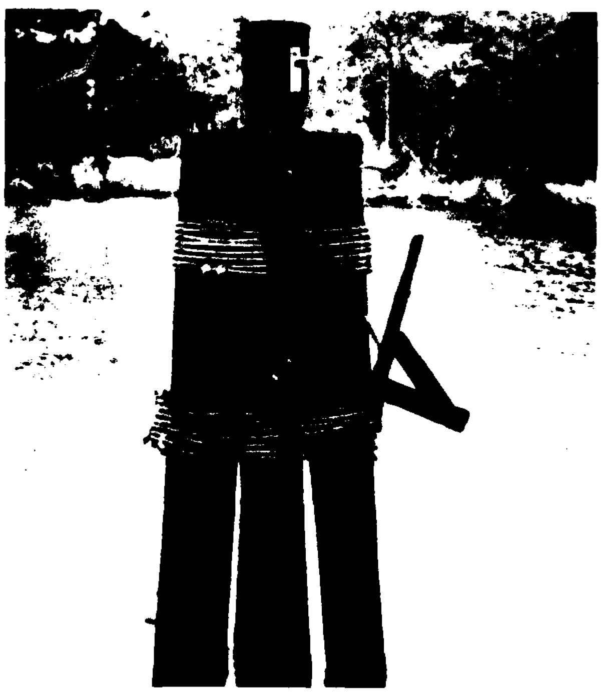
Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

GROUND PHOTOGRAPHY

Dolphins Bordering Canal Shore



Detailed View of Dolphin Structure

OPTIMUM FILM/FILTER COMBINATIONS

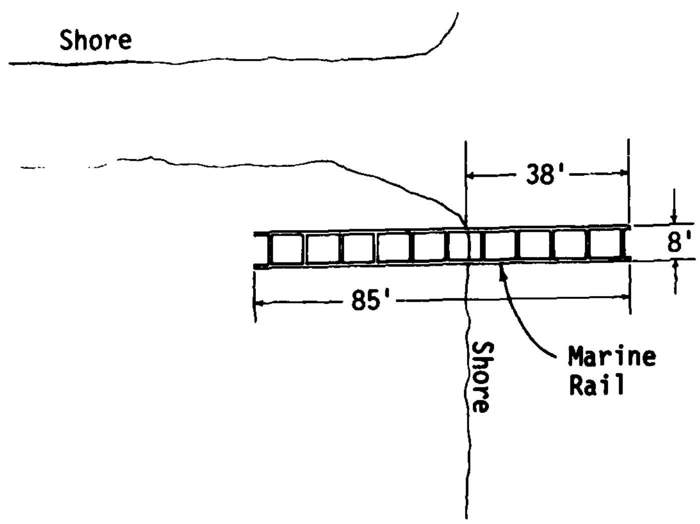
The dolphins presented in this example are constructed by clustering 5 or 6 creosoted timber pilings. The diameters of the clusters viewed vertically downward are approximately 30 in. Given the types of film used in the examples of this catalog, this diameter is the resolvable threshold for 12,000 ft (see Part IV in the main text). Above this altitude the dolphins cannot be detected. Below this altitude, the dolphins become increasingly easier to resolve. In this example, two of the dolphins can barely be seen in the color film. They can also be inferred by the docked tug and barge. However, the shadows prevent detection in the black and white. Following are the optimum film/filter combinations for dolphins.

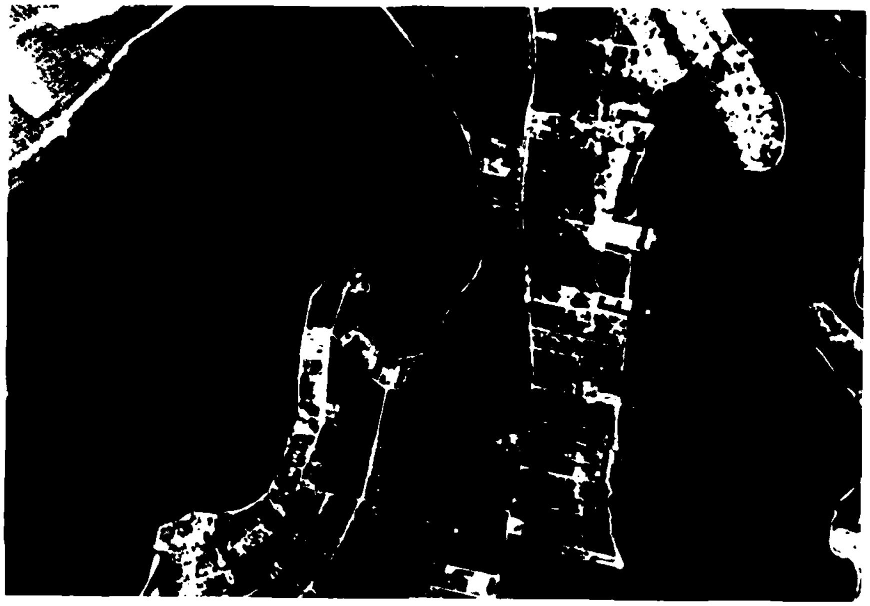
Priority	Film	Filter	Contrast Index
1	2443	3	0.84
2	2443	12	0.83
3	2448	3	0.79
4	2424	87C	0.39

MARINE RAIL

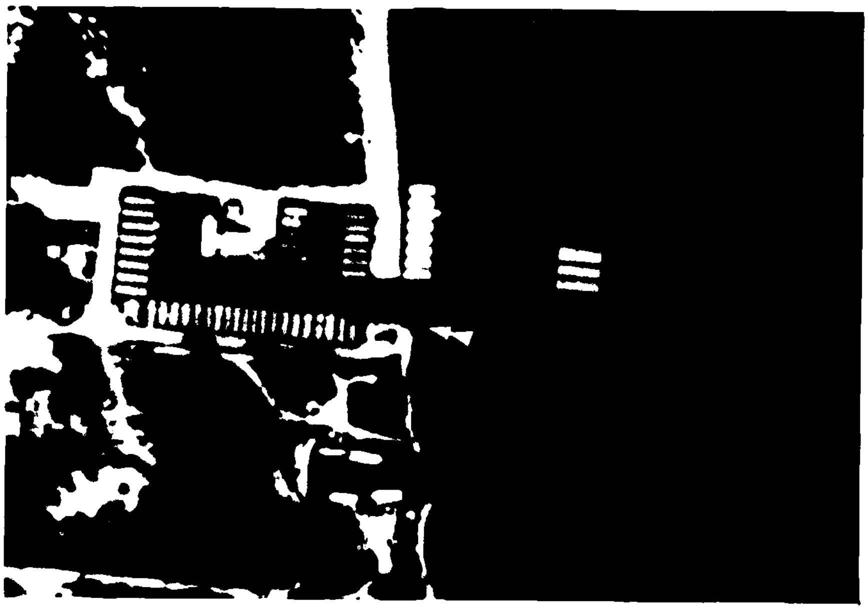
DESCRIPTION: An iron marine rail 8 ft wide by 85 ft long, 38 ft of which extend into the water

ILLUSTRATION:



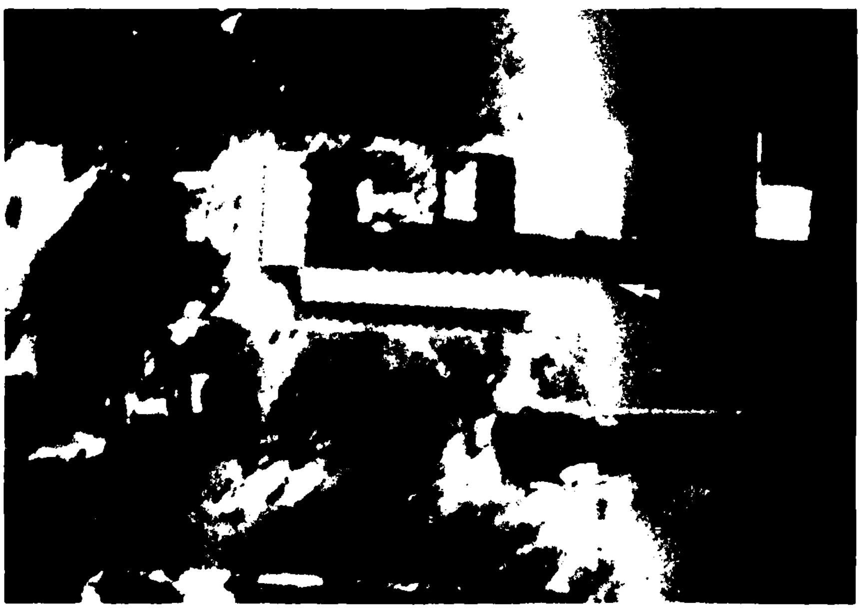


Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

GROUND PHOTOGRAPHY

Marine Rail Projecting into Water

Structure Used to Drydock Boats

AD-A087 584 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 14/5
REMOTE-SENSING PROCEDURES FOR DETECTING AND MONITORING VARIOUS --ETC
APR 80 H STRUVE, W L KIRK
UNCLASSIFIED WES/TR/EL-80-1 NL

5 of 5
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Marine Rail and Shadow

OPTIMUM FILM/FILTER COMBINATIONS

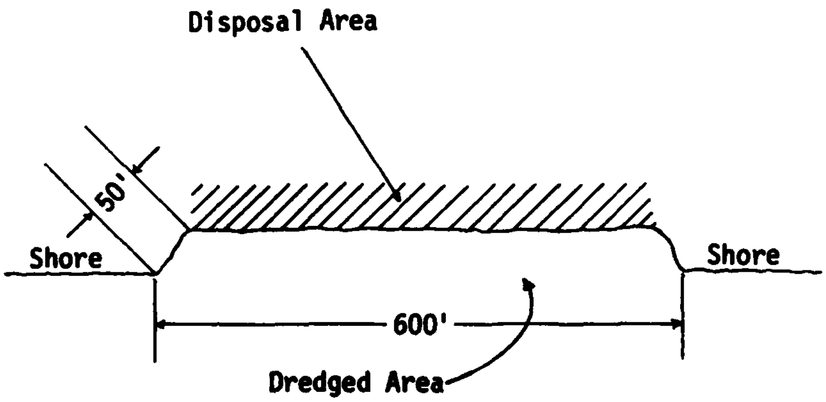
The marine rail presented in this example is constructed of two narrow railroad tracks. The width of a rail as viewed vertically downward is approximately 5 in. This width is not resolvable from 12,000 ft with either the black-and-white or the color film used to produce this catalog (see Part IV in the main text). However, two parallel dark lines appear in both the black-and-white and the color photography. This seems to contradict the spatial limitations governing the resolvability discussed in the text. An on-site inspection of the marine rail revealed that the tracks were elevated above the ground and caused shadows to form under and parallel to the tracks. Thus the total width of shadow plus track was sufficient to become

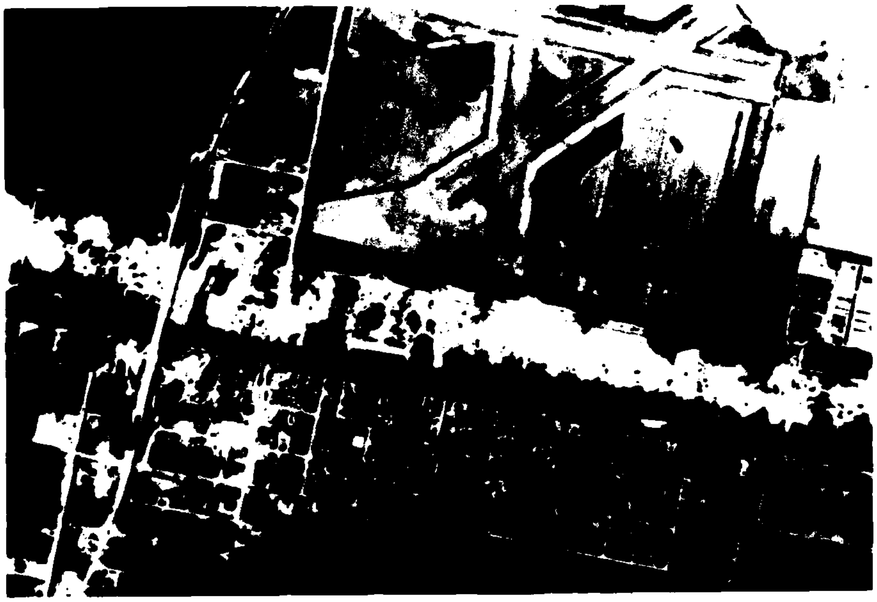
resolvable and can plainly be seen in the photography. Since the effects of shadows were not considered in this report, no optimum film/filter combinations were generated for the marine rail.

LAND DISPOSAL AREA

DESCRIPTION: Dredged area 50 by 600 ft with a depth of 8 ft. Approximately 20,000 cu yd of material removed by dragline and deposited on upland property

ILLUSTRATION:





Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Dredged Area Viewed from Opposite Shore

Upland Disposal Site

OPTIMUM FILM/FILTER COMBINATIONS

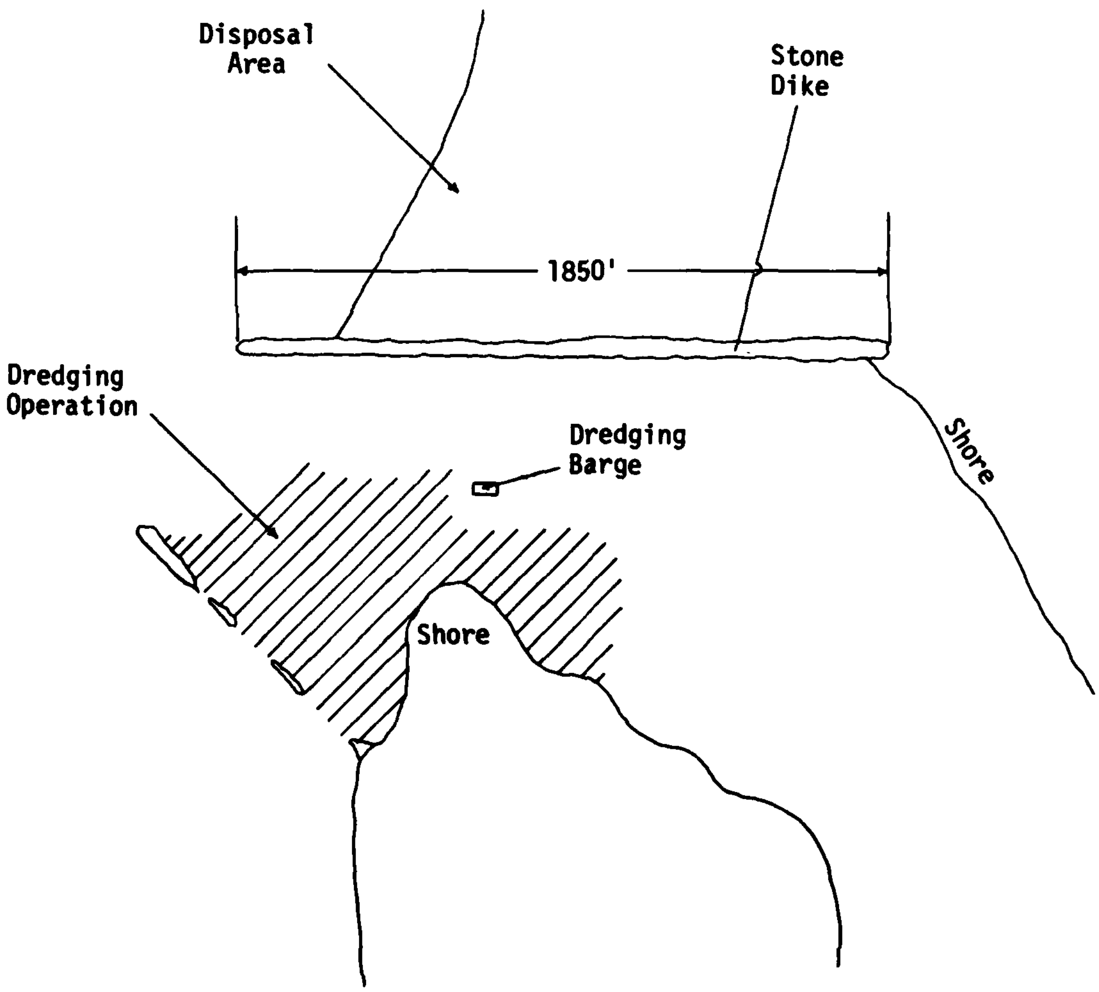
Feature: Beach Sand
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	3	3.53
2	2448	3	3.52
3	2443	12	3.48
4	2424	87C	1.16

LAND DISPOSAL AND DREDGING

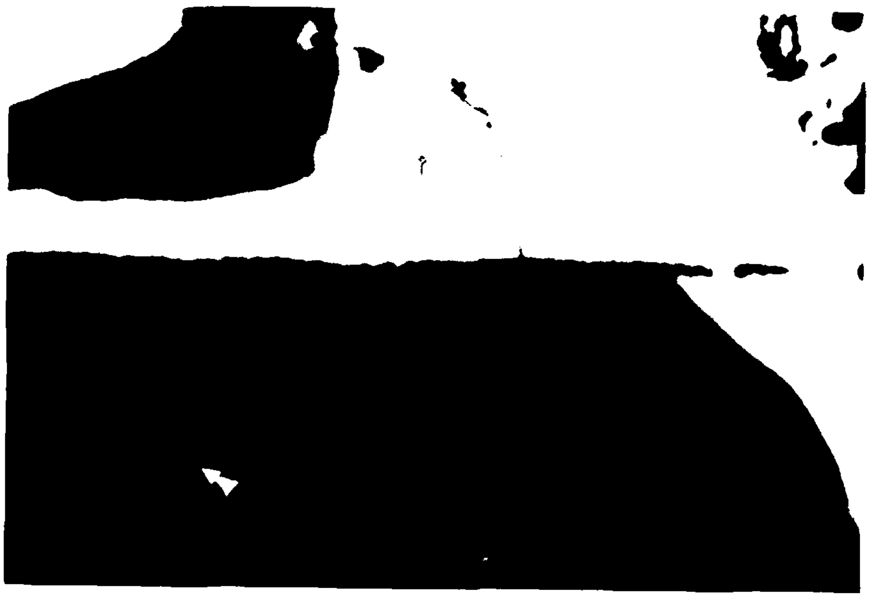
DESCRIPTION: Maintenance dredging of the western section of Perdido Pass. Dredged material disposed on upland sites adjacent to stone dike

ILLUSTRATION:



COLOR INFRARED AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000



Enlargement of Feature Area

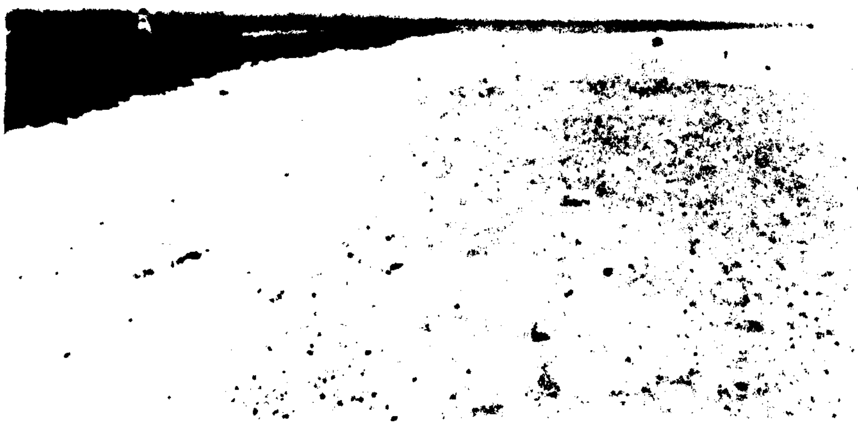
BLACK AND WHITE AERIAL PHOTOGRAPHY

Feature Area at a Scale of 1:24,000

Enlargement of Feature Area

GROUND PHOTOGRAPHY

Upland Disposal Site



Area of Disposal Site Near Stone Dike

OPTIMUM FILM/FILTER COMBINATIONS

Feature: Water less than 1.0 yd but greater than 0.5 yd in depth
Background: Water greater than 1.0 yd in depth

Priority	Film	Filter	Contrast Index
1	2443	12	0.39
2	2443	3	0.36
3	2424	87C	0.26
4	2424	89B	0.25

Feature: Beach Sand
Background: Water less than 1.0 yd but greater than 0.5 yd in depth

Priority	Film	Filter	Contrast Index
1	2448	3	3.27
2	2443	3	3.17
3	2443	12	3.09
4	2402	47B	1.00

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Struve, Horton
  Remote-sensing procedures for detecting and monitoring various activities regulated by the Mobile District / by Horton Struve and William L. Kirk. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.
  117, [269] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; EL-80-1)
  Prepared for U. S. Army Engineer District, Mobile, Mobile, Ala.
  References: p. 115-117.

1. Aerial photography. 2. Detection. 3. Multispectral scanners. 4. Remote sensing. I. Kirk, William L., joint author. II. United States. Army. Corps of Engineers. Mobile District. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; EL-80-1.
TA7.W34 no.EL-80-1